THE ENGINEER.

Modern Air Compressors.

AIR COMPRESSORS.

DURING the last fifteen or twenty years the use of compressed air, not only for the purpose of transmitting power to distances, but as a useful medium for employment in many industrial processes, has made such great strides, that the building of air compressors has become a very important department of mechanical engineering.

It is not very long since the firms who were devoted to the construction of air compressors could almost be counted on the fingers of one hand, and now, in this country alone, there are more than twenty firms devoting a large part of their energy to the manufacture of these machines. The development of the use of compressed air as a means for transmitting power appears the more remarkable when it is remembered that during this same period the use of electricity for the same purpose has grown enormously.

In those cases where it is equally admissible to use compressed air or electricity, the discussions as to the relative merits of the two have been long and heated, and the advocates of each system have backed their arguments with forcible reasoning. This is especially true where power is to be transmitted in coal mines. It cannot be denied that both systems have their decided merits and demerits; but the fact that compressed air has not only not been ousted from its leading position by electricity, but has itself made great advances, must surely be an indication that it possesses intrinsic qualities of its own, which in many instances make its use imperative. It is still a disputed point as to how far electric transmission is safe for use in fiery mines.

The fact that compressed air continues to occupy such a strong position as a means of transmitting power is largely due to its cheapness, its cleanliness, and to the simplicity of the processes involved in its use. In some special cases the fact that the exhaust air, after it has done its work, can be used to support life and light and for cooling, is a factor much in its favour; this is the case in mines and in underground and submarine workings. It will presently be seen that, besides its use for pure and simple transmission of power, the air itself can be employed in many processes where, on account of the peculiar character of the work, they could not be carried out by any other means.

What takes place during the compression of air is pretty well known. When air is compressed, all the work done upon it is converted into heat, whose immediate effect is to raise the temperature of the air, causing it to occupy at a given pressure a greater bulk than if it were at its original normal temperature. This heating of the air causes a loss of power in two ways—first, by increasing the work which has to be done in compressing and discharging the air; and, secondly, by a shrinkage taking place in the air pipes. The least amount of work which is needed to compress a pound of air to any given pressure is that which is required to compress it isothermally—that is to say, with the temperature maintained at the normal throughout the process of compression and delivery. If it requires 100 horse-power to compress isothermally a certain quantity of air per minute to a given pressure, then that compressor would have 100 per cent. total efficiency which, apart from engine friction,

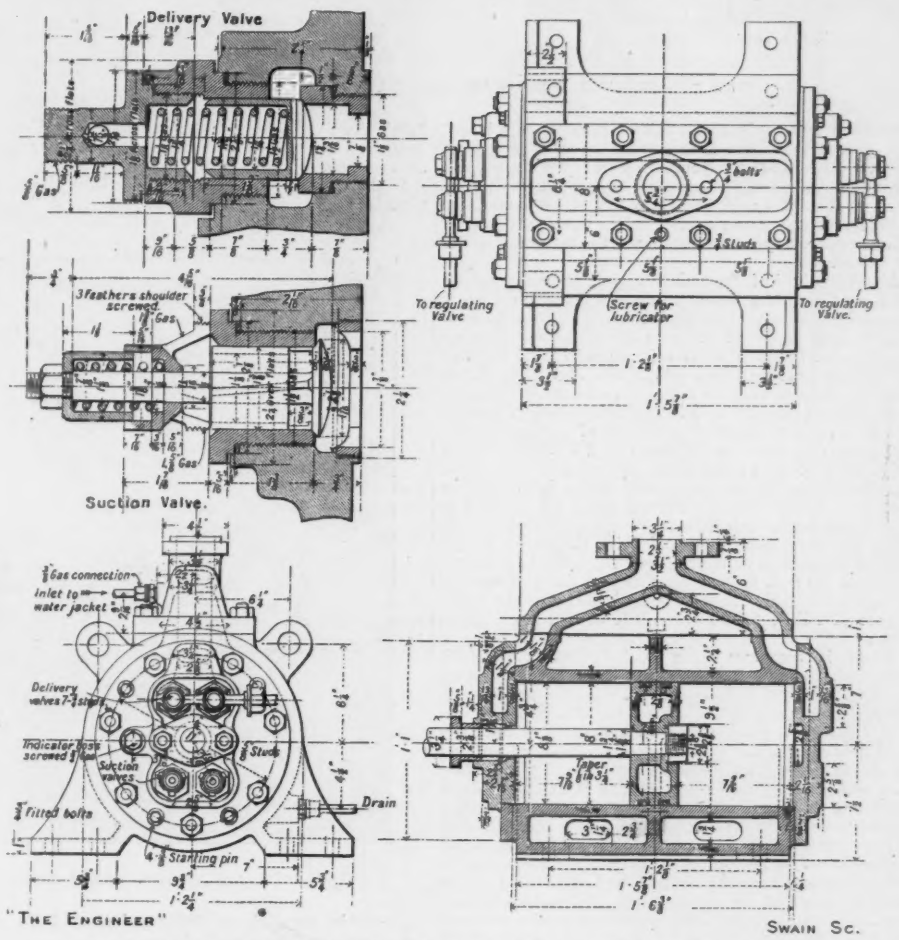


Fig. 2.—SECTION OF AIR CYLINDER AND VALVES—SIR W. ARROL AND CO., LTD.

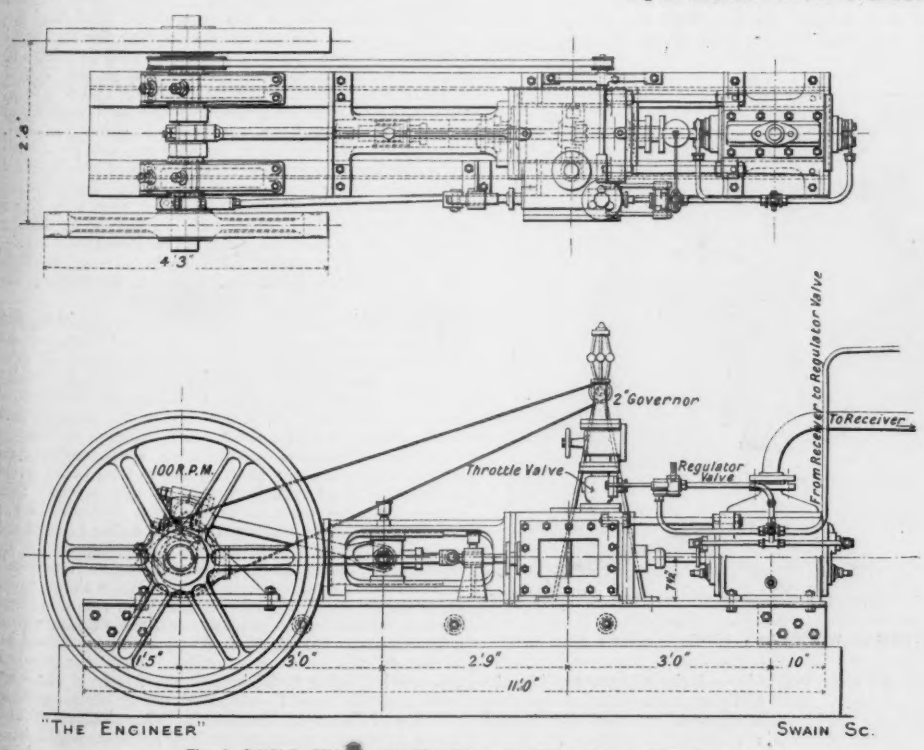


Fig. 1—SINGLE STAGE COMPRESSOR—SIR WM. ARROL AND CO., LTD.

could effect this compression by the expenditure of only 100 horse-power. This is never possible in practice, and there must always be some heating of the air. One of the objects of air compressor design is to reduce this heating as far as possible, and so reduce the consequent loss and raise the efficiency. This heating of the air is the cause of the first loss. In addition there is the unavoidable friction of the moving parts, whether steam-engine friction, air-cylinder friction, or the friction of the rotating parts in belt-driven and electrically-driven compressors.

Besides these two main causes of loss of power between its source and the compressed air there are numerous smaller losses, due to the friction of the air in passing through the ports and valves, the work needed to raise automatic valves, and so forth. The ratio of the work of isothermal compression to the actual work required is often called the commercial efficiency. In the case of steam-driven compressors this is the ratio of the isothermal work to the combined area of the indicator cards taken from the steam cylinders. This is possibly the best form in which to reckon the efficiency of a compressor, because it takes into account all the possible sources of loss to which a compressor is liable.

Another point to which most designers pay a great deal of attention is the volumetric efficiency, that is, the ratio of the actual volume of air at atmospheric pressure, or free air taken into the compressor per minute, to the volume swept out by the low-pressure air piston in the same time.

The requirements to be fulfilled by an air compressor which is to be in all respects satisfactory to the user are the following:—The volumetric efficiency should be high; the power-cost of running the machine ought to be low, or, in other words, the commercial efficiency should be high; the cost for repairs and upkeep should not be high; and, of course, the first cost must be as low as is compatible with the other qualities. To these qualifications it is often necessary to add that the compressor must

occupy little floor space and make as little noise as possible when running. All these qualities should be well balanced, and not, as is often the case, some one particular feature brought to a high state of perfection to the neglect of all the others. In reading descriptions of the air compressors produced by the different makers it will be apparent that there is still great diversity of opinion on several of the most important points in the design, and it is quite clear that the compressor has not yet settled down to fixed laws of design to the same extent, for instance, as the steam engine. The principal points of difference in compressor design are to be found in the air valves.

About one half of the makers appear to prefer the old form, consisting of a simple mushroom valve held against its seat by a spring. It is probably held by these makers that for compressors of moderate size which may possibly be subjected to rough usage it is better to build a strong serviceable machine which will, in the first place, do its work at all times with the minimum amount of care, and, in the second place, will do it with a moderate efficiency. There are many hundreds of cases of compressors of small capacity where a difference of 1 or 2 per cent. in efficiency is of little importance as compared with other considerations. As an instance of this it is well known that the Westinghouse air-pump used on railways is one of the most uneconomical compressors made. But there are thousands in use and doing their work to the perfect satisfaction of their users. Any gain in economy would at the best only amount to very little, and would not compensate for the extra complication and the added chance of failure to act which this complication might incur.

When, however, we come to the compressors which deal with large quantities of air at the expenditure of, possibly, hundreds of horse-power, the case is different. These larger compressors are mostly steam driven, and 1 or 2 per cent. gain in commercial efficiency means a good deal of fuel, and therefore of money saved, so long as this is not won at the expense of much greater first cost and expenditure in repairs. It is in these larger machines that most care has been expended on designing, with the object of attaining a high all-round efficiency.

Unfortunately, in this respect also, unlike the steam engine, there is very little published information as to either the actual or the comparative efficiencies of the different types of air compressors. No doubt relatively few complete efficiency tests have been carried out, and the majority of makers do not seem anxious to publish such results as they have obtained, except, perhaps, in the case of volumetric efficiencies. To this last most makers appear to pay an unusual amount of attention. Possibly if more complete efficiency tests were carried out, a great deal of valuable information could be collected which would serve to guide designers on many vital points, and would undoubtedly ultimately benefit the users. Regarding the question of volumetric efficiency, nearly all the makers rate the capacity of their compressors by saying that they are capable of dealing with so many cubic feet of free air per minute. It seems as if, when this is done, some mention ought to be made of the volumetric efficiency, or the statement is indefinite. Why not give the capacity, as in the case of one firm, as the volume of compressed air actually delivered per minute?

In the descriptive matter which follows the range of view is necessarily restricted to the most important features in the designs of the various makers. It has become almost the universal custom for these makers to build their compressors so as to be suitable for driving either with steam cylinders, from an electric motor, direct or through gearing, or by means of a belt in cases where power is available and the compressor is not a very large one. This last plan is found to be especially suitable for use in works where compressed air is wanted for working pneumatic tools and machinery. Where pressures are required up to about 80 pounds gauge, the compression is generally carried out in one stage, though some makers seem to prefer to make two-stage compressors even for this pressure. This is more especially the case in the larger machines, where the saving to be gained by adopting two-stage compression becomes more apparent.

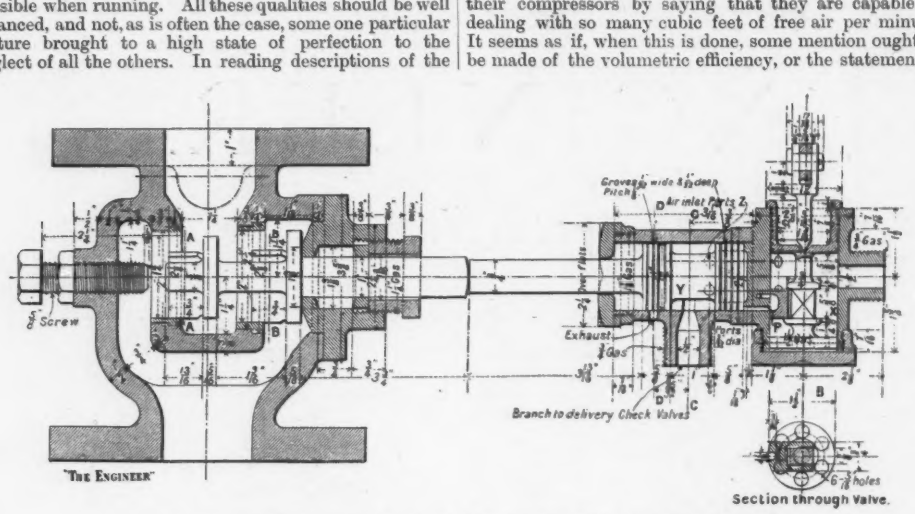


Fig. 3.—AUTOMATIC REGULATING DEVICE—SIR W. ARROL AND CO., LTD.

It is obviously impossible to deal here with anything like all the typical compressors made, and only the most important and representative of these have been selected for illustration and description. In order to give greater facility for comparison, the machines of any one type will, as far as possible, be kept together, beginning with the simpler forms of compressors fitted with automatic valves.

In Fig. 1 is shown a general arrangement of a steam-driven single-stage compressor made by Sir William Arrol and Co., Limited, of Glasgow. Here the steam cylinders are 10½in. diameter and 15in. stroke, working at 60 lb. per square inch steam pressure. The air cylinder is 8in. diameter and 15in. stroke. The air pressure is 100 lb. per square inch, and the capacity 70 cubic feet of free air per minute. The air valves are automatic and controlled by springs. They are placed in the covers of the air cylinder, as shown in section in Fig. 2, the suction and delivery valves being shown separately. These are made of hard phosphor bronze, and are provided with large areas of wearing surface.

An automatic regulating apparatus is provided for the purpose of controlling the compressor when the demand for air is intermittent. This is bolted direct to the steam throttle valve, and the regulation is effected by holding the delivery valves open, and at the same time closing the steam throttle valve when the air in the receiver attains its maximum pressure. This apparatus is shown in section in Fig. 3. It consists of two cylinders, one vertical and the other horizontal, bolted together, and in communication with the receiver. The air inlet ports in the horizontal cylinder can, however, be closed by its piston Y. The vertical cylinder X contains a piston and a small slide valve for the purpose of admitting the pressure air to or exhausting the air from the horizontal cylinder Y, whose piston is in contact with the piston of the steam throttle valve C. The piston in the vertical cylinder is held down by means of a lever and weight as long as the air does not exceed the required pressure, and when in that position the slide valve is open to exhaust. The piston in the horizontal cylinder also acts as a valve by admitting pressure air to the back of the delivery valves, or by exhausting the air when the pressure becomes too high. The delivery valves shown by Fig. 2 are in the form of pistons, and are ground to fit the conical seats in the back guide covers on which they sit, when the pressure air behind them is taken off through the piston in the horizontal cylinder uncovering the exhaust port

When the vertical piston is in its normal position, that is to say down, the ports Z are uncovered, and pressure air from the receiver is in this way allowed to pass through the vertical cylinder into the horizontal cylinder, and thence by means of pipes to the back of the delivery valves. At the same time the exhaust port in the under side of the horizonal cylinder is covered by the piston. If the pressure of the air in the receiver gets beyond the normal the load on the vertical piston overcomes the downward pressure of the weight. This causes the slide valve to uncover the port P, and the pressure of the air is allowed to pass to the back of the horizontal piston, which, moving along, closes the air inlet port Z, opens the delivery valve pipes to exhaust, and closes the steam throttle valve. When the pressure air at the delivery valves is exhausted the valves are held open by the receiver pressure, and, the suction valves being thus kept closed, the main piston moves to and fro in air at the receiver pressure. When the receiver pressure has fallen to the normal, the weight of the lever overcomes the upward pressure of the air on the vertical piston and forces it downwards. The slide valve also moves down and opens the back of the horizontal piston to the atmosphere. At the same moment the steam

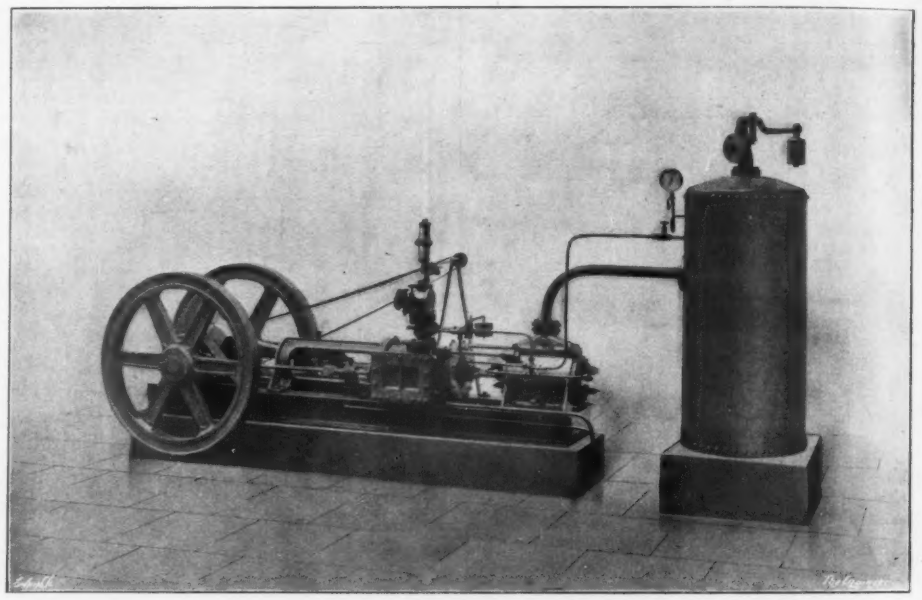


Fig. 4.—STEAM COMPRESSOR—SIR W. ARROL AND CO., LTD.

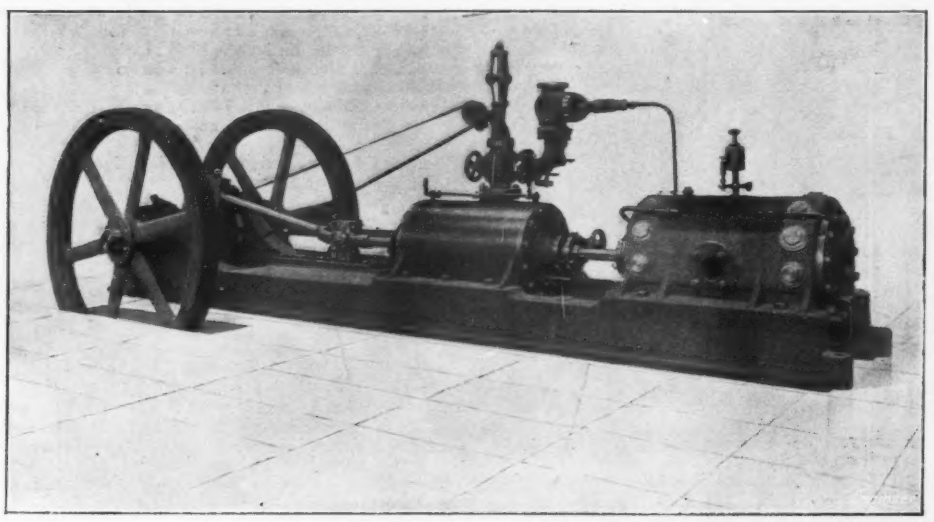


Fig. 5.—SINGLE STAGE COMPRESSOR—THOMAS WHITE AND SONS

forces back the throttle valve spindle and with it the horizontal piston, which then covers the exhaust port and opens the pressure-air port to the back of the delivery valves again. The makers say that in this way they get a very close regulation, amounting to about 3 per cent. from the normal. A general view of this machine is shown by Fig. 4.

A general view of a steam-driven single-stage compressor by Thomas White and Sons, of Paisley, is shown in Fig. 5. That shown is one of the firm's standard sizes, having a steam cylinder 15in. diameter, air cylinder 15¼in. diameter, the two being in tandem with a 24in. stroke. Its capacity is 498 cubic feet of free air per minute when running at 100 revolutions per minute. In the air cylinder, which forms the principal feature to be noticed, the valves are of the automatic kind, made from nickel steel, and very light; they are of small diameter, but several are used, and, combined, give a large port area. This, the makers find, gives a higher volumetric efficiency than a smaller number of valves each of larger diameter. The piston is allowed to pass partly over the valve openings, so that there may be very little lost space at the end of the stroke, and at the same time it is made impossible for a valve to drop into the cylinder in the event of its breaking. The valves are made interchangeable, and can be quickly removed by merely unscrewing the cap shown in the illustration. Both the cylinder barrels and covers are water-jacketed. The governing is effected by the pressure in the receiver when it reaches 100 lb. per square inch, closing the inlet pipe, so that the piston works in a partial vacuum. At the same time a small piston is operated, which, acting on a double-beat throttle valve, shuts down the steam until the compressor is doing no more than just turning round. This control is checked by a high-speed governor fitted to the steam cylinder. The makers of this compressor are strongly of opinion that the slow-speed compressor is by far more efficient than one which runs at a high piston velocity.

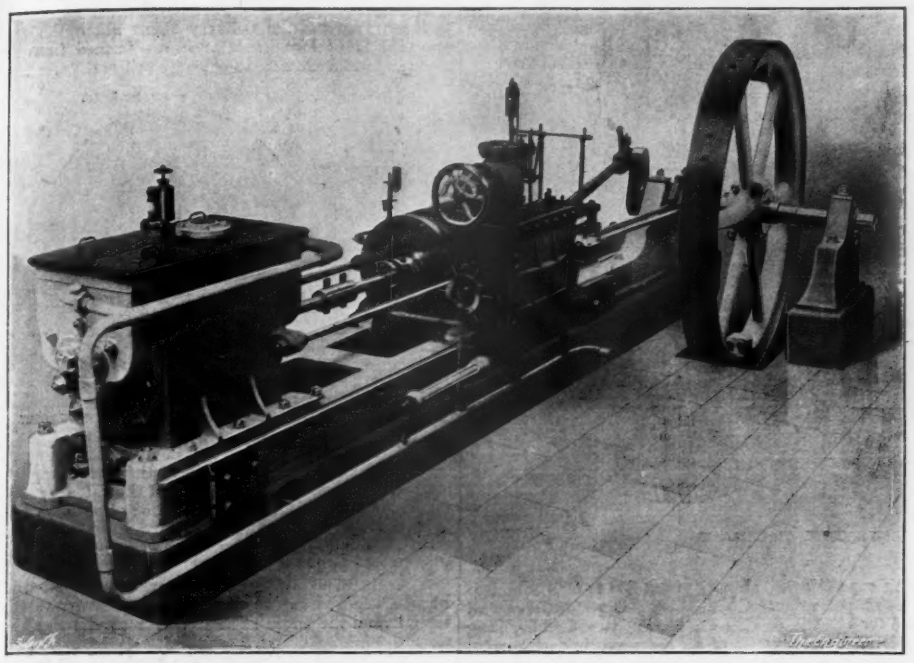


Fig. 6—SINGLE STAGE COMPRESSOR—THOMAS LARMUTH AND CO.

The compressors built by Schram, Harker and Co., of London, are chiefly intended for mining and general contractors' work. They include both fixed, semi-portable, and portable machines, single and two-stage. This firm lays particular stress upon its special suction valves, the seats of which are fitted with guides to equalise the internal and external diameters of the valve seats, in order to minimise the suction that must otherwise occur in a valve seat of such area as is required in an air compressor working at high pressure. All the compressors made by Schram, Harker and Co. are fitted with valves which are entirely automatic in their action. The extra work which would be required to lift the suction valves is minimised by the above arrangement, by which the valve is put into equilibrium, and the delivery valves are fitted with a silent cushioning gear, which renders them practically noiseless, and reduces the shock when working at high pressure.

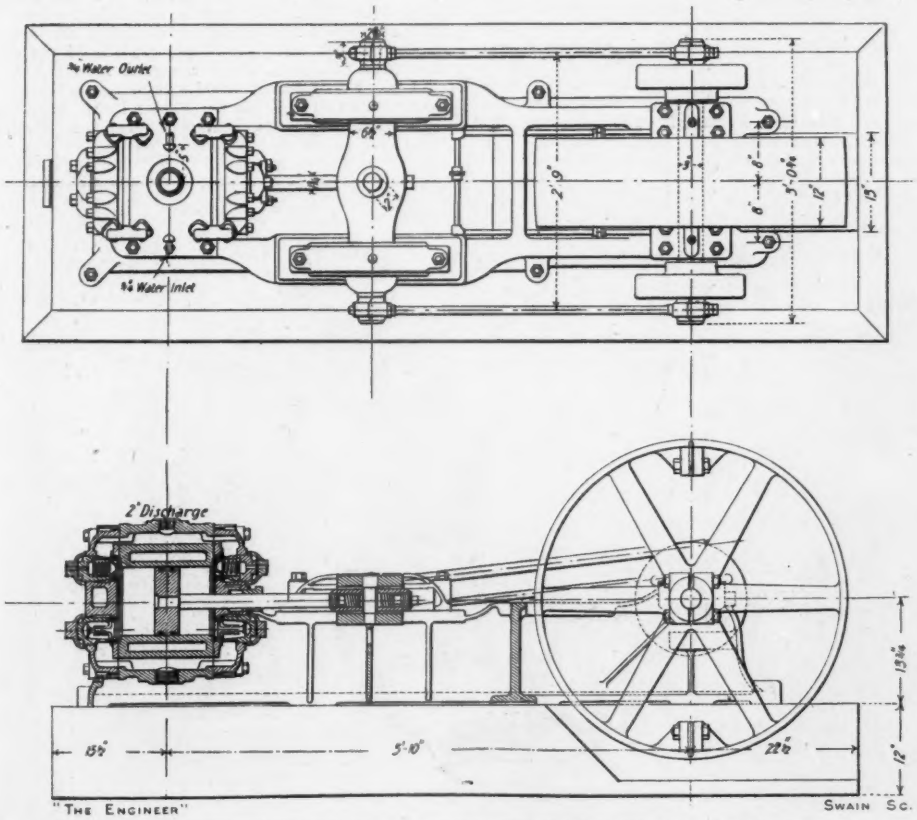


Fig. 7.—SINGLE STAGE COMPRESSOR FOR H.M.S. CYCLOPS—THE CONSOLIDATED PNEUMATIC TOOL CO., LTD.

Fig. 6 illustrates a compressor of standard design by Larmuth and Co., of Salford. This firm aims at building a sound compressor of simple design, which can be relied upon to work with a fair efficiency with little attention and costing little for repairs and renewals. There is no complication of valve gear for the air cylinders, the air valves being of the spring controlled automatic type. The particular machine shown in the illustration is steam driven, the steam cylinders being 13in. diameter with a stroke of 24in. The air cylinder is of the same diameter; it is cooled by a circulation of water through the jackets, and the portion of this water space at the top of the cylinder is left open, being simply covered with movable plates, so that the temperature of the water in the jackets can always be ascertained. All the parts are so arranged that the machine can be duplicated by coupling up a second and similar machine alongside the first. These compressors are in most cases intended to compress up to about 80 lb. per square inch in one stage.

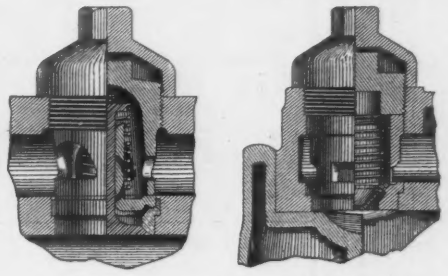


Fig. 8—SUCTION AND DELIVERY VALVES

The compressors made by the Consolidated Pneumatic Tool Company, Limited, are also of the automatic valve class, both suction and delivery valves being controlled by springs. The general scheme of the design will be gathered from an inspection of the drawings—Fig. 7. This represents a single-stage compressor supplied to the British Admiralty for use on H.M.S. Cyclops. The power is derived from shafting, from which the pulley flywheel of the compressor is driven, the reciprocating movement of the air piston being obtained by means of connecting-rods working from the cranks atthe two ends of the crank shaft. The valves are shown in their places in the section in Fig. 7 and more in detail in the two views in Fig. 8. In the design, particular attention has been bestowed on the proper placing of the inlet and discharge valves. It will be seen that these are brought as near as possible to the faces of the cylinder covers, so as to reduce the clearance volume to a minimum, and in this way ensure a high volumetric efficiency. The valve seatings are so placed that there may be a free circulation of cooling water round about them, so as to keep the suction air as cool as possible, and also because it is found that by keeping the valves and casings cool their life is materially prolonged. It will also be seen that both discharge and inlet valve seats are removable from the cylinders; in this way renewal is made easy. The valve seats—Fig. 8—and the cages are made of a hard grade of cast iron, and the valves themselves from steel forgings. It is found that this combination of steel forging, working on a hard cast iron seating, gives very good results as regards wear. Of the views in Fig. 8, that on the left represents a suction valve, and that on the right hand a delivery valve. Compressors of this type are made in various sizes, having capacities of free air per minute varying from 95 cubic feet to 600 cubic feet. The particular machine shown here has an air cylinder of 9in. diameter, with a stroke of 10in. They are also made to be driven by steam or electricity. In addition to these single-stage compressors, this firm also builds two-stage machines, compressing up to 100 lb. per square inch, the air being taken through an intercooler between the low and high-pressure cylinders. A section of one of these intercoolers is shown in Fig. 9. It will be seen that the water passes upwards through some 380 thin brass tubes,

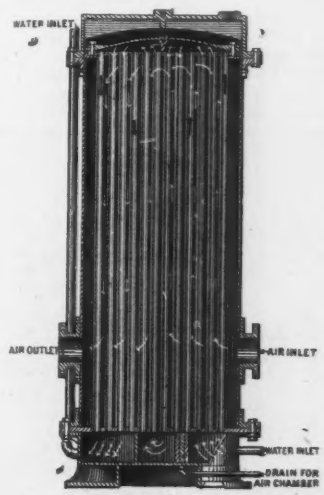


Fig. 9.—INTER-COOLER—THE CONSOLIDATED PNEUMATIC TOOL CO., LTD.

around the outside of which the air, as it passes through the intercooler, travels.

The machines which have been mentioned so far have all been of the spring-controlled automatic valve type, and mostly working in one stage. In compressors of this kind the present tendency seems to be to adopt steel

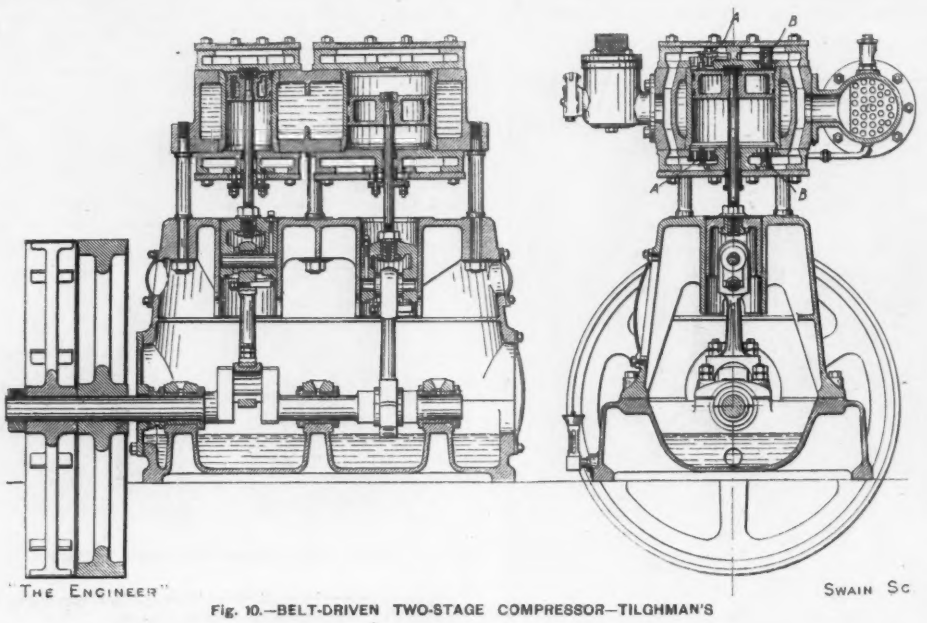


Fig. 10.—BELT-DRIVEN TWO-STAGE COMPRESSOR—TILGHMAN'S

forgings for the valves themselves, or in some cases valves of phosphor bronze, and to have these working on hard cast iron seatings.

The two next machines to be described embody what the makers regard as a simplification and improvement of automatic valves by making the valves themselves of

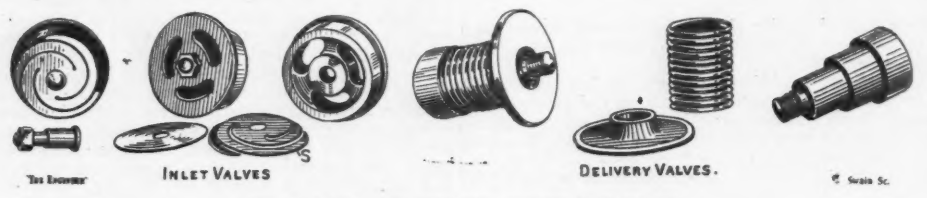


Fig. 11—INLET AND DELIVERY VALVES—TILGHMAN'S

thin plate steel working on flat cast iron seatings, somewhat in the same way as the Kinghorn valve used for marine air pumps. The first compressors where this arrangement was adopted were those made by Tilghman's Patent Sand Blast Company, Limited, of Broadheath, near Manchester, and were originally constructed for supplying compressed air for sand blasting.

This company makes a number of different types of the smaller sizes of air compressors, including machines which are belt, steam, and electrically driven, and are arranged as both single and two-stage compressors. They can be roughly classified into two groups, namely, those which depend entirely upon automatic valves, and those which are controlled by positive piston valves. The section shown in Fig. 10 represents one of the former of these classes. This is a vertical belt-driven two-stage compressor, being one of a type intended to supply air up to a pressure of 130 lb. per square inch, and having capacities which range from 150 to 600 cubic feet of free air per minute. This design is particularly well suited for electric driving as, having two double-acting cylinders, four deliveries of air are given in each revolution, and in this way a practically constant load is kept on the motor. This is held by the makers to be a very important feature in the modern air compressor, as so many are now electrically driven. They also hold that for the smaller sizes of compressors automatic inlet and delivery valves are preferable to mechanically controlled valves owing to their freedom from complication. The special feature of the compressor here illustrated is the use of Matthewson's patented valves and springs on the inlet side of the cylinder ends where small clearance is necessary. These inlet valves simply consist of discs of thin sheet steel resting on a seating formed from a solid casting, through which a number of holes are drilled to provide the passages for the air. These are shown in place at A A on the right-hand view taken through the valve chambers in Fig. 10, and more in detail in Fig. 11. It will be seen that the springs which keep the valves in place are of a spiral form, stamped out of a disc of steel. The valves are exceedingly light, and occupy very small space in proportion to their effective area. An air passage equivalent to one-fifteenth of the piston area is obtained with a clearance of less than 2 per cent. of the cylinder capacity, and the weight of a 3in. valve and spring is under two ounces. The result of this lightness is an entire absence of the hammering so often associated with the working of automatic air valves.

The valves on the delivery side, where the space occupied is of less importance, are formed from steel stampings, and are held in place by coil springs. These

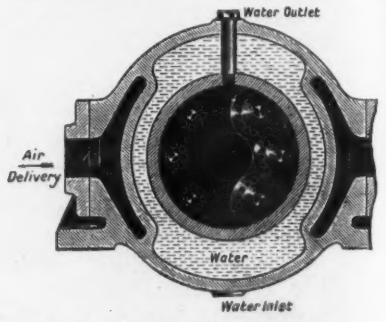


Fig. 13—SECTION OF TILGHMAN'S COMPRESSOR

are made of such pitch and length that when compressed to the required lift of the valve they are completely closed, and in this way the shock of the valve against a fixed stop is avoided. The difference of pressure which is required to open a delivery valve is ¼ lb. per square inch. These delivery valves are shown in place at B B, Fig. 10, and in detail in Fig. 11.

A sectional plan through the cylinder is shown by Fig. 13, in which can be seen the three delivery valves at the left and the three suction valves at the right-hand side.

It will be noticed that only the barrels of the cylinders are jacketed, it being impossible to jacket the covers, as these are taken up as valve chambers. The makers claim that greater efficiency is obtained by utilising the cylinder ends as valve chests than by using radial valves and water jacketing the cylinder ends, the increased valve area obtainable and the reduction in clearance more than compensating for the extra cooling which would be effected. When it is considered that in a small compressor, say one of 300 cubic feet capacity, a single stroke or compression only occupies about one-eighth of a second, it cannot be expected that much cooling will take place in the cylinder in that time. Undoubtedly the only place where thorough cooling can be effected is in the intercooler, where the velocity of the air over the cooling surface is very low. The makers say that as a proof of this they are able to guarantee a volumetric efficiency of over 90 per cent., and from 80 per cent. to 85 per cent. commercial efficiency, which are good for small compressors. These results are for two-stage compressors when working up to 150 lb. per square inch. With their single-stage compressors of this type the makers guarantee 80 per cent. to 85 per cent. volumetric efficiency, and mechanical efficiency of 70 per cent. to 75 per cent. when working at 80 lb. per square inch.

The low-pressure cylinders of the two-stage compressors are fitted with relief valves set to blow off at 35 lb. per square inch, in this way making it impossible for the low-pressure cylinders to have to carry the full pressure in the

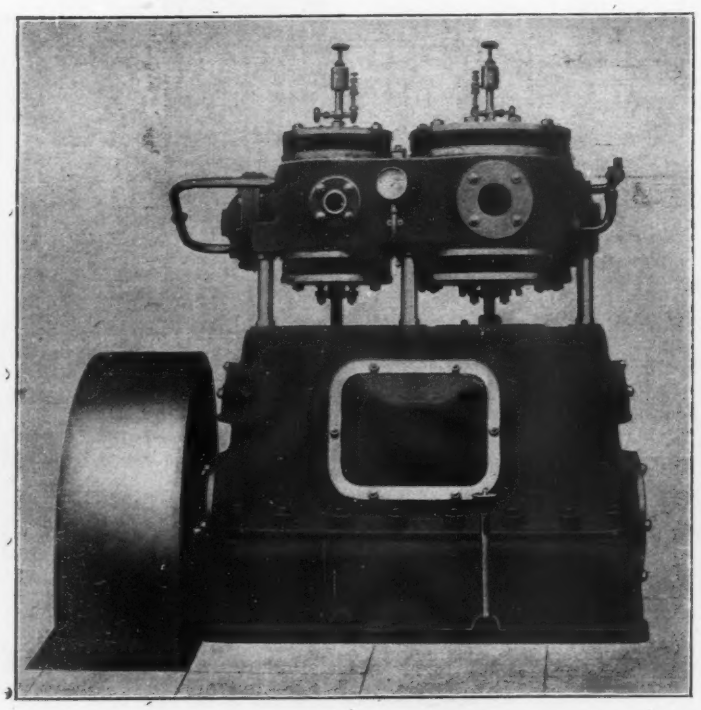


Fig. 12—BELT-DRIVEN TWO-STAGE COMPRESSOR—TILGHMAN'S

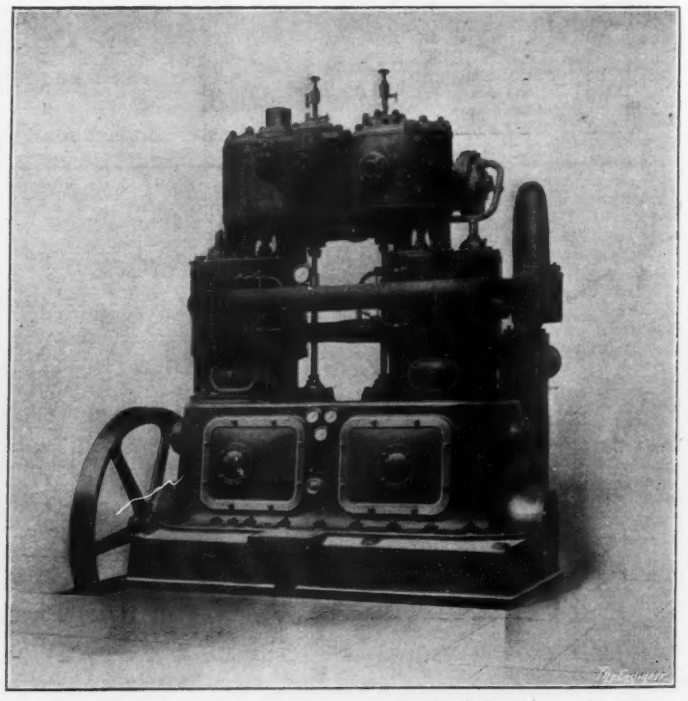


Fig. 14—VERTICAL TWO-STAGE COMPRESSOR—TILGHMAN'S

event of a valve breaking in the high-pressure cylinder. The intercoolers are of sufficient volume to maintain an even pressure. They are fitted with small brass tubes, through which the water is circulated as shown in section at C, Fig. 10.

The automatic governing valve shown to the left of the cylinder regulates the amount of air compressed to that which is required. When the amount of air required is less than the capacity of the compressor, the air pressure in the receiver rises, and by means of a small weighted piston, air is admitted from the receiver to the governor cylinder, in this way closing the air inlet and putting the high-pressure pistons into equilibrium by causing a partial vacuum on both sides of the piston.

All the bearings are lubricated automatically by the splash system, the crank pins working in a bath of oil.

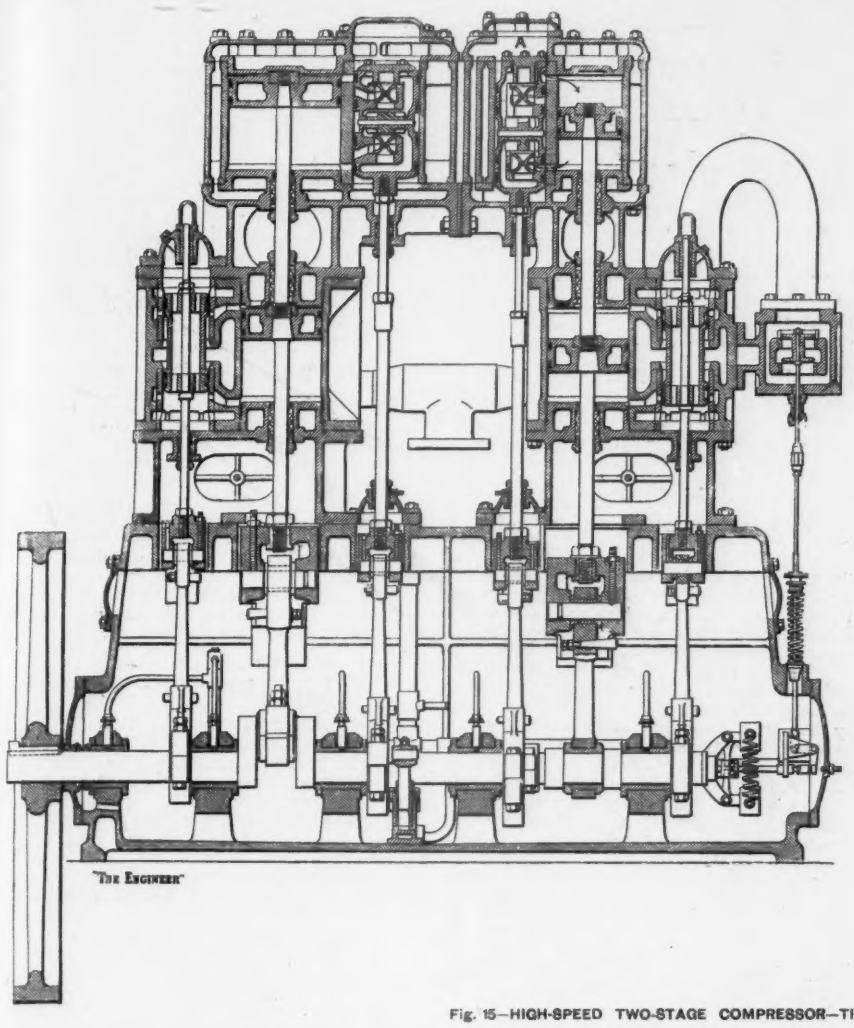


Fig. 15—HIGH-SPEED TWO-STAGE COMPRESSOR—TILGHMAN'S

Fig. 12 is a general view reproduced from a photograph of the compressor which has just been described. Vertical sections taken through cylinders and valve chests, and a side elevation of a new type of compressor recently introduced by the same firm, are shown by Fig. 15. The particular machine illustrated is a vertical high-speed, steam-driven, two-stage compressor. The steam cylinders and air cylinders are in tandem, the former being simple and fitted with piston valves. Above the left-hand steam cylinder is the low-pressure air cylinder, whose piston is carried by a continuation of the steam piston-rod; while above the right-hand steam cylinder is placed in a similar manner the high-pressure air cylinder. Both these air cylinders have their suction and delivery controlled entirely by piston valves. Referring to the high-pressure air cylinder of the figure, the piston is moving downwards, and the piston valve moving upwards. Air is being drawn from the inter-cooler through the space A, which is put into communication with the inside of the cylinder by the upper portion of the valve. This communication exists until the piston reaches the bottom of its stroke, when the lower edge of the valve port reaches the upper edge of the cylinder port and cuts off the supply. While this is going on above the piston the piston valve has moved into such a position that communication exists between the lower part of the cylinder and the delivery space in the interior of the valve itself. This space is in communication with the delivery outlet, but before the air can get to this outlet after leaving the cylinder it must pass through a light double-beat equilibrium valve which automatically closes when the main piston arrives at the end of its delivery stroke. In this way the air which has been delivered is prevented from returning. These inside valves are very light, and there are no springs to control them, so that there is no throttling of the air, but back leakage is effectually prevented. The same cycle takes place at both ends of the cylinder, and the same thing happens in the low-pressure cylinder, with the exception that the suction takes place from the atmosphere and delivery into the intercooler. This last consists of a set of ¾in. copper tubes through which water circulates, the air to be cooled passing round them. Baffle plates are provided in order to enable the hot air to part with as much of its heat as possible. There is, of course, an automatic governor supplied, in which the air suction is automatically cut off when the air pressure exceeds a certain prearranged amount, and a partial vacuum is produced on the two sides of the low-pressure piston.

In the compressor illustrated the common stroke is 8in., diameter of high-pressure air cylinder 8½in., of low

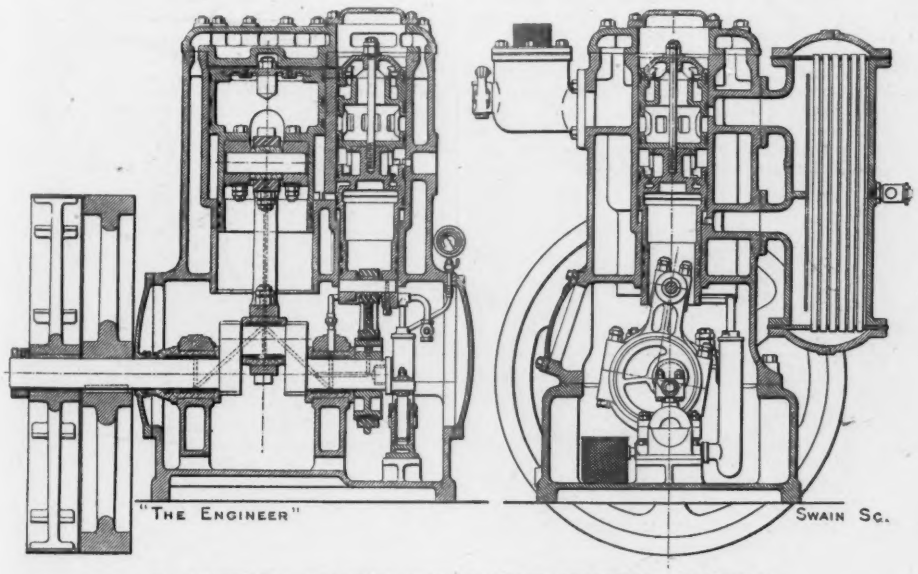


Fig. 16—VERTICAL TWO-STAGE SINGLE-CYLINDER COMPRESSOR—TILGHMAN'S

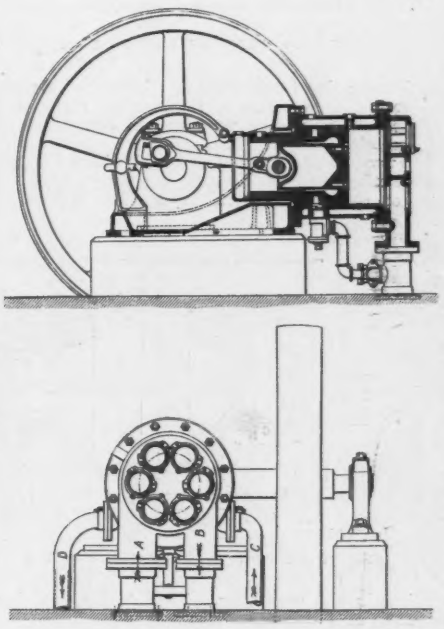
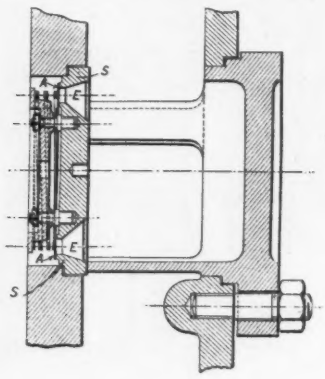


Fig. 17—SINGLE-CYLINDER TWO-STAGE COMPRESSOR—BORSIG

pressure air cylinder 14½in., and of both steam cylinders 10½in. The air pressures in the intercooler and receiver respectively are 30 lb. and 100 lb. per square inch. On a test the volumetric efficiency was found to be 93·4 per cent., and the commercial efficiency, or the ratio between the theoretical amount necessary and the actual horse-power required to compress the same amount of air isothermally, was found to be 70 per cent.

These compressors are arranged for all the usual ways of driving, and in sizes having capacities from 400 to



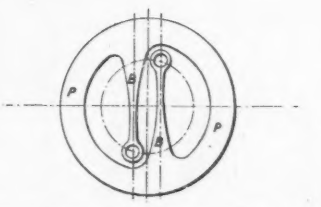


Fig. 18—SECTION OF BORSIG'S AIR VALVE

2500 cubic feet per minute. Besides the sectional views, Fig. 15, a view taken from a photograph is given in Fig. 14.

Fig. 16 shows a section of a high speed vertical belt-driven two stage compressor which is similar to the last in all respects but one, namely, that the compression is effected in one cylinder instead of two. A differential trunk piston is used, the top of the part above the large diameter piston forming a single-acting low-pressure cylinder. The lower part of the cylinder has a smaller diameter, and the

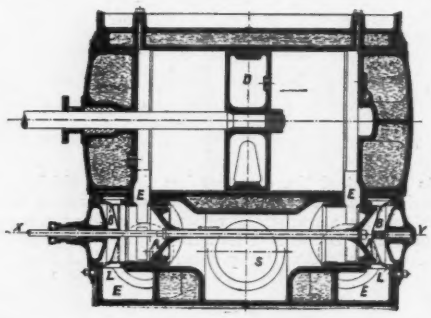
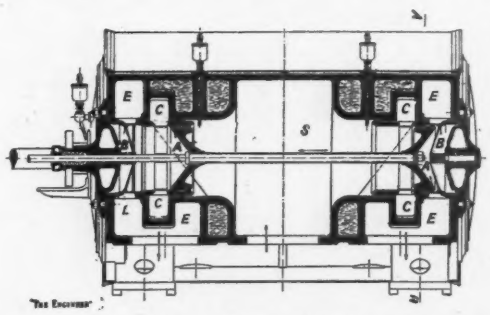


Fig. 19—SECTIONAL PLAN OF KOSTER COMPRESSOR

annular area due to the difference between the areas of the two pistons forms a single-acting high-pressure cylinder. This makes a very compact compressor suitable for belt driving at a high speed.

The two-stage compressor, arranged with a differential single-acting piston, seems to be becoming popular with users of compressed air in cases where the quantity



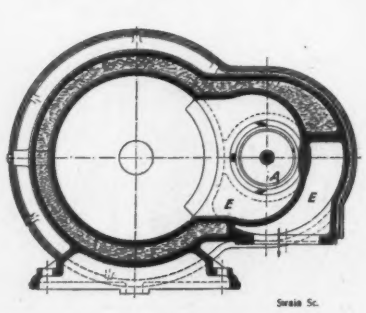


Fig. 20—SECTION THROUGH VALVE-BOX OF KOSTER COMPRESSOR—W. H. BAILEY AND CO., LD

required is not very large. Herr A. Borsig makes a speciality of a compressor of this type, which is shown in section and end elevation in Fig. 17. The machine is belt-driven, and like others of the same class, has its connecting-rod linked directly to the trunk piston. It will be seen that there are six valves arranged on the cover of the low-pressure end, three of these being for the admission of the free air, and the remaining three for the discharge of the low-pressure compressed air on its way to the intercooler and the suction of the high-pressure end. On the end elevation the suction pipe is marked A, the discharge passage from the low-pressure end is B, the admission pipe to the high-pressure end is marked C, and the final discharge passage for the high-pressure air D. All the valves, both suction and delivery, made by Herr Borsig are of his patented plate valve design. One of these valves, complete with valve and casing, is shown in detail by Fig. 18.

The air passes towards the valve by way of the open-

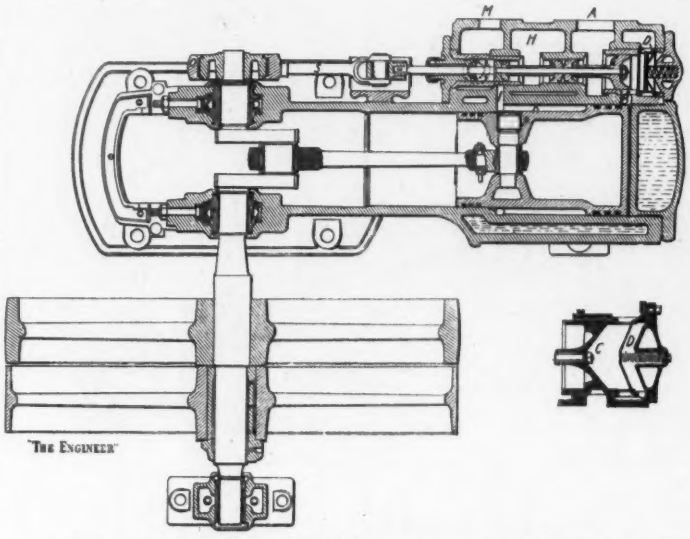


Fig. 21—TWO-STAGE KOSTER COMPRESSOR—W. H. BAILEY AND CO., LTD.

ings in the casing marked E, which are arranged in a circle on the end of the casing. These openings are closed on the pressure side by a plate valve A, and marked P on the lower view. These are held against the flat seatings by the light springs shown, and are retained in their central position by the two arms marked B, whose ends are fixed to the seating, and movement of the plate valve can take place to and from the seating by the play allowed by the spring of these arms, so that in this way the valves are guided without friction.

W. H. Bailey and Company, Limited, of Manchester, have within the last two years taken up the manufacture of what is to engineers in this country a new type of compressor, made under the patents of Herr E. W. Köster, who, we understand, has been turning out a large number of these machines in Germany for several years past. Two principal types are at present made, namely, double-acting, single-stage or two-stage compressors, which are either steam-driven, belt-driven, or motor-driven; and a second type, in which the compression is two-stage and is effected by a single trunk differential piston working as a single-acting compressor. In both types the essential features are the following:—The air suction is effected and controlled by positive-driven piston valves, and the delivery of the compressed air takes place through lightly-controlled spring piston valves, after being allowed to reach them through the positive piston valves.

The sections, Figs. 19 and 20, represent views taken through the cylinder and the valve box of a double-acting compressor fitted with Köster's valves. The free air enters the space S through a suction pipe. Here it will be seen that the main piston is moving to the left, and is in the middle of its stroke. The piston valve A is now in such a position that the air can pass freely from S into the annular space C, Fig. 20, which forms part of the port leading to the cylinder, the air passing freely in without throttling. The suction valve remains open until the end of the suction stroke, when it again closes. Looking now at the left-hand end of the valve box, the piston valve has established a connection between the port and the annular space C and the discharge chamber E. On the left-hand side of the piston, the air which has been drawn in during the previous stroke is being compressed, and when it reaches the final pressure the second valve B opens, and the compressed air is discharged into the space E. At the same time the piston valve is moving towards the left, and closes the ports C C precisely at the moment the piston reaches the end of its stroke. The result of this last motion is that the piston valve prevents communication between the left-hand side of the piston and the discharge chamber E, and between the right-hand side of the chamber and the suction space S.

The piston D now moves in the opposite direction, and during this time the piston valve passes through its middle position to the left opening the port C at the left-hand end of the cylinder and the port C at the end of the discharge chamber E. By having this positive piston inlet valve providing a free opening for the air, and in this way minimising negative work and heating of the incoming air by throttling, a high volumetric efficiency is maintained. The clearance space is kept as low as possible, and it will be seen that the covers and casings are water jacketed as far as is practicable. These factors both lead towards a high volumetric efficiency. In Köster's valve gear the clearance space is from 1½ per cent. to 3 per cent., according to the size of the compressor, and a volumetric efficiency of from 92 per cent. to 98 per cent. is obtained.

At the point in the compression stroke when discharge begins the piston valve port is open, and remains so until the end of the stroke is reached by the piston, the extent of the opening being in reality greater than is necessary for the quantity of air which passes. So that, as far as the piston valve is concerned, there is no throttling of the discharge whatever, and only the spring valve has to be considered in this connection. This valve B is so designed as to offer the least possible resistance, and to act without shock. In order to have it as light as possible it is made of forged steel. It has no spindle, and slides easily as a piston in its cylinder. The spring used to keep the valve on its seat is a very light one, and at its maximum compression only offers a resistance of some 2½ oz. of surface pressure. The cushion of air

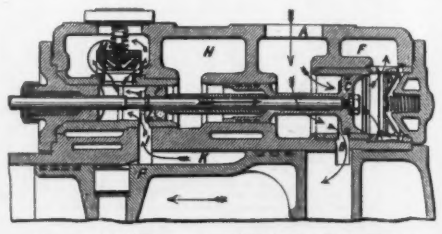


Fig. 22—VALVES OF TWO-STAGE COMPRESSOR

offers practically no resistance to the movement of the valve, but limits the opening at the last moment, when the valve has passed beyond the opening which connects the space at the back with the outlet passage. The lift

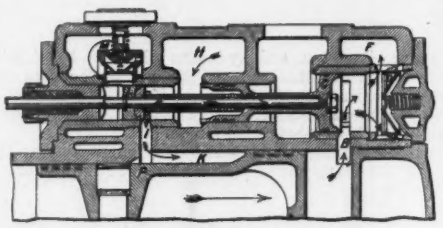


Fig. 23—VALVES OF TWO-STAGE COMPRESSOR

of the valve is one-fourth its diameter, so that the maximum opening is provided for the passage of the air.

An automatic valve must close precisely at the end of the stroke when the crank pin passes the dead centre. If this does not occur, the air may flow from the receiver

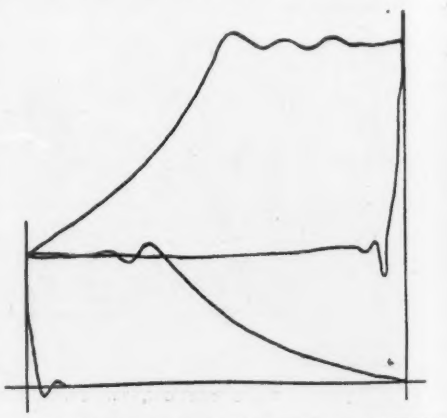


Fig. 24—DIAGRAMS OF TWO-STAGE KOSTER COMPRESSOR

back into the cylinder and bring the valve down on its seat with a certain amount of force. With a high lift and heavy valve this blow is considerable, and the result is that in the case of an automatic valve the lift must be limited to a small amount and the valve kept extremely light. These defects are obviated in the Köster valve

gear owing to the fact that it is the piston valve which closes the pressure port on the reversal of the stroke, and a back flow of air is prevented. In the Köster gear the spring valve is closed by a very light spring pressure, because, the air pressure being the same on both sides at the moment of closing, no more force is required than is sufficient to overcome the slight amount of friction. The closing is not dependent on time, so that it may close in a leisurely manner after cutting off the connection with the cylinder by the piston valve. Thus the time of closing for a given valve is the same for all speeds, and for this reason it is possible to run the compressors at very high speeds. The makers of this compressor lay stress on the fact that the three fixed points in a compression cycle, namely, the opening of the inlet, the closing of the inlet, and the closing of the discharge, are with this valve gear positively and mechanically controlled, and the opening of the discharge, which is the only variable point in the cycle, is controlled by an automatic spring valve, which is relieved of the necessity for quick closing by the piston valve, is consequently noiseless in action, and is far less likely to wear out than in the case of automatic delivery valves. We ourselves have seen some of these compressors at work, and were much struck by the total absence of valve "click." One of these machines, capable of dealing with 7000 cubic feet of free air per minute, runs at 600 revolutions per minute.

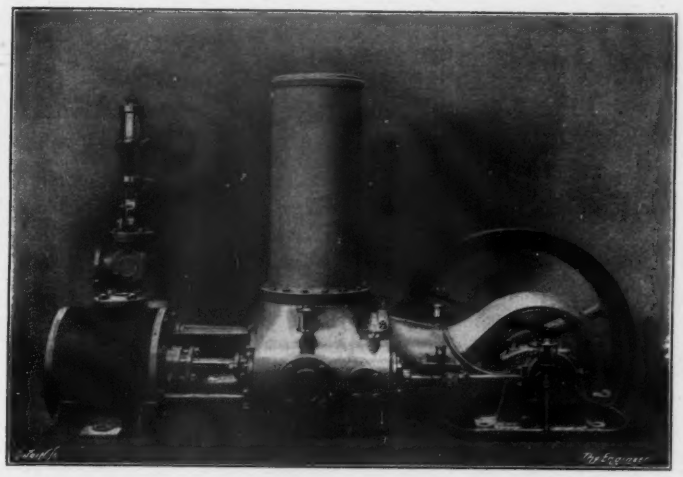


Fig. 25.—STEAM-DRIVEN TWO-STAGE KOSTER COMPRESSOR—W. H. BAILEY & CO., LTD.

Where a double-acting compressor of the kind just described is arranged for two-stage compression, the air is taken through an intercooler in passing from one cylinder into the next. The type of intercooler used on all these compressors consists of a coil of air pipe surrounded by a bath of water which is always changing, and in this way kept cool.

In one of the compressors of this type the capacity of the machine is 1765 cubic feet of free air per minute. The air cylinders are 26·57in. and 16·73in. respectively for the low and high-pressure cylinders, with a stroke of 33·46in., and a speed of 80 revolutions per minute. The actual horse-power to be provided in the steam cylinders to deliver air at 100 lb. per square inch is from 320 to 337.

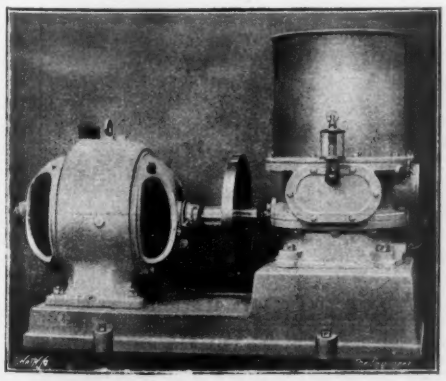


Fig. 27.—MOTOR-DRIVEN KOSTER COMPRESSOR

The second type of compressor, made by W. H. Bailey and Co., is also fitted with the Köster valves, but differs from the last in that it always compresses the air in two stages; this two-stage compression is effected in one cylinder fitted with a differential trunk piston, and the compressor must of necessity be single-acting. A sectional plan of one of these machines is shown in Fig. 21.

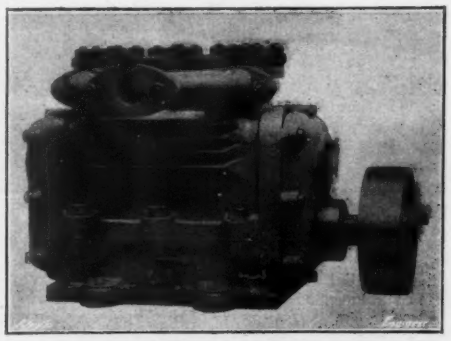


Fig. 28.—SMALL VERTICAL KOSTER COMPRESSOR

In this case the compressor is driven from a belt working on to a fast and loose pulley. The connecting-rod links on to a gudgeon pin, which is fitted into the trunk piston. The arrangement of the valves, which, as before, are of the piston type, is shown more in detail in Figs. 22 and 23. In Fig. 22 the piston is shown moving to the left, and free air is being drawn into the space between the right-hand end of the piston and the cylinder cover. The action here is exactly like that previously described, the air being sucked in through the opening at A, and thence through the ports B. On the completion of this low-pressure suction stroke, the admission valve is closed, and the piston returns towards the right, as shown in Fig. 23. Here the end of the low-pressure compression stroke is being approached, and the compressed air is being discharged into the space F, through the port B, and past the spring valve D. This completes the low-pressure cycle.

The air compressed in this way to the pressure of the first stage passes from the chamber F, through the intercooler and back to the suction space of the high-pressure end H. In Fig. 23 the piston is moving towards the right, and the air in H is being drawn into the annular space between the larger part of the cylinder and the part of the piston which has the smaller diameter. This space is marked K. As before, the suction process is controlled by a piston valve. The delivery stroke of this high-pressure end is shown on Fig. 22. The only difference between this delivery valve and that already described is that the spring valve port is placed in a vertical position for convenience of removal for cleaning. The cooling arrangements are good, the water jacket completely surrounding the air piston, the cylinder head, and the air valve chest. In Fig. 24 is shown a pair of diagrams taken from one of these two-stage compressors. These diagrams suggest an unrestricted suction volume and low resistance to the air in passing through the valves between the two stages and the intercooler.

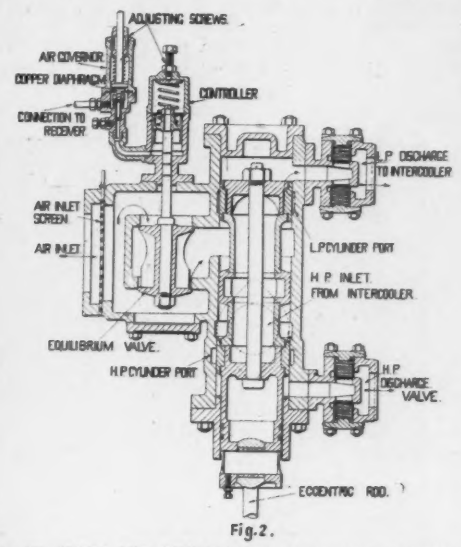


Fig. 2.

Fig. 29—ALLEY AND MACLELLAN'S AIR VALVES—SECTION

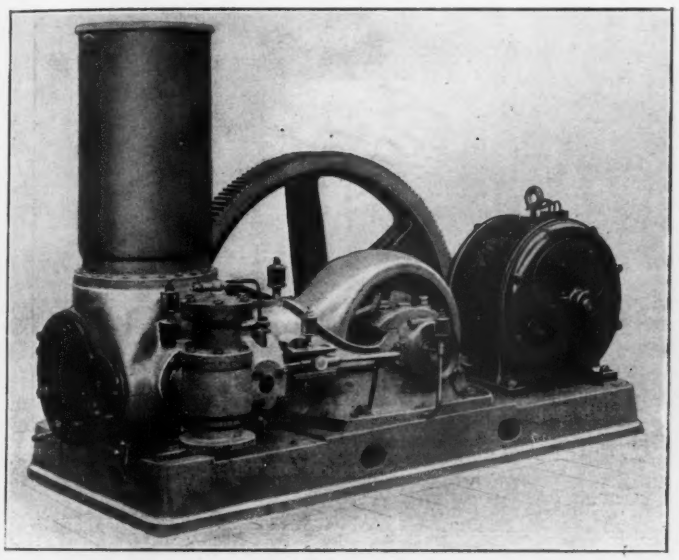


Fig. 26—TWO-STAGE SINGLE-CYLINDER KOSTER COMPRESSOR—W. H. BAILEY & CO., LTD.

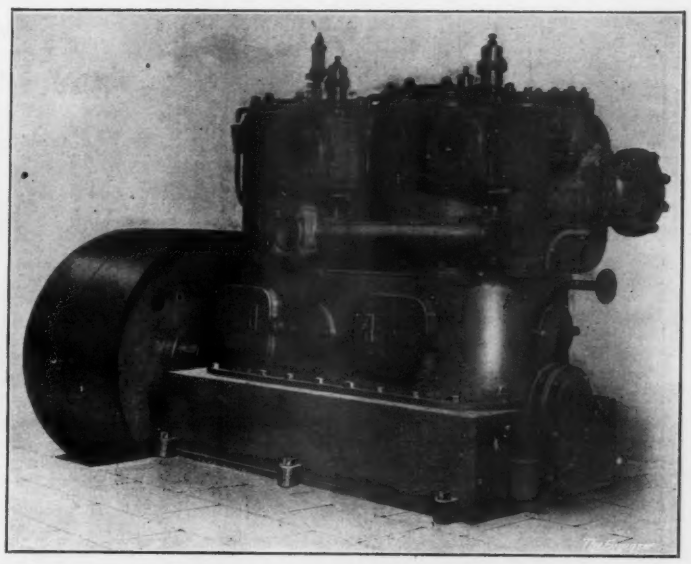


Fig. 30—TWO-STAGE BELT-DRIVEN COMPRESSOR—ALLEY AND MACLELLAN, LTD.

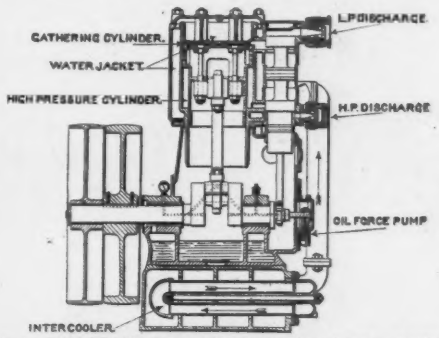
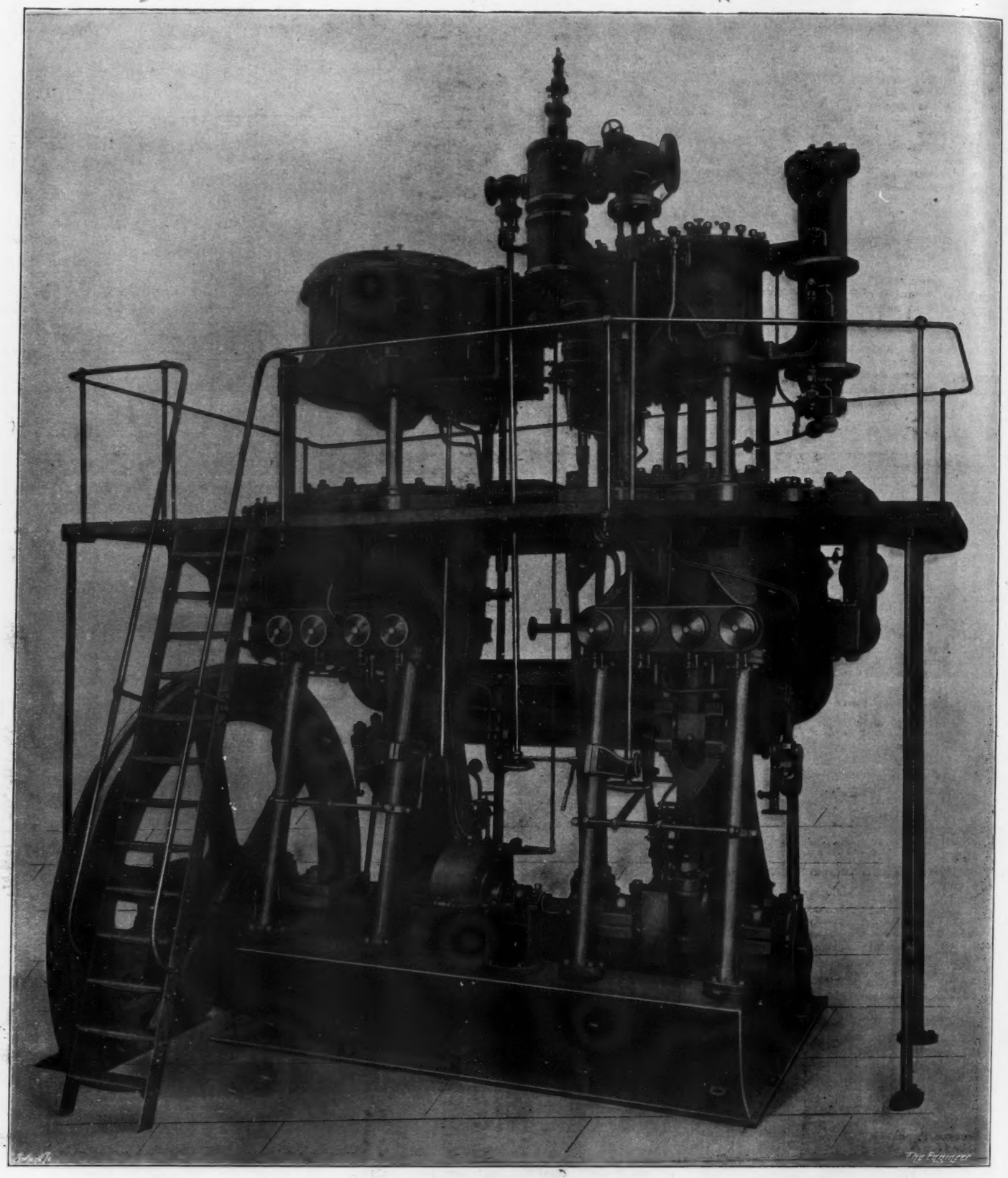


Fig. 31—TWO-STAGE BELT-DRIVEN COMPRESSOR—ALLEY AND MACLELLAN, LTD.

The makers of the Köster compressors contend that by using a positive piston inlet valve, the cylinder, which is

well water-jacketed, is filled quite full of air at the beginning of the compression stroke; and in this way a very high volumetric efficiency is attained; that in the act of opening, the piston inlet valve, besides admitting the free air, also displaces the compressed air remaining in the clearer spaces of the valve chest; and, further, that the air is compressed in the cylinder to a pressure equal to and no higher than the pressure in the discharge pipe, and passes through a single valve of large size and high lift, which is air cushioned in opening, and on the completion of the discharge stroke the air passage from the cylinder is closed mechanically, so that the delivery valve is permitted to seat itself slowly and quietly.

Several general views are taken from photographs of the two-stage in one one-cylinder type. Fig. 25 is steam-driven, direct compressing 78 cubic feet of free air per minute in two stages up to 90 lb. per square inch. The tall cylindrical vessel above the air cylinder is the inter-cooler, which consists of a coil of the air pipe surrounded by a large volume of constantly changing water. Above the steam cylinder is the air control valve, which slows down the engine when the air in the receiver attains the maximum pressure. Fig. 26 represents a compressor driven by a motor through gearing. Figs. 27 and 28 are views of directly driven small compressors of the vertical type. The same Köster gear is used, but the whole machine is more compactly designed than in those heretofore described. The second of these is a compressor which was specially designed for operating compressed air brakes on electric trains. It will be seen that in this case no attempt is made to water jacket the cylinders, but a radiator is relied upon.



F.g. 32—TWO-STAGE DOUBLE-ACTING COMPRESSOR—ALLEY AND MACLELLAN, LTD.

The essential feature in the design of compressors made by Messrs. Alley and MacLellan, of Glasgow, is to be found in the arrangement of the air valves. Like the Köster valve just described, the air valve made by this firm is of the piston type for suction. In the case of delivery the valve which actually prevents the return of the delivered air is a light spring-controlled valve, or a set of these placed in one casing. Air is admitted at the beginning of the suction stroke by the opening of the piston valve to the suction passage, and this valve again closes precisely at the end of the suction stroke. When the maximum pressure is attained the compressed air passes through the open port and thence through the spring valve, which it lifts into the discharge passage. At the end of the compression stroke the piston valve closes and prevents the return of any air, even if it could pass the spring valve, which is automatically shut as soon as the piston has completed its compression stroke. In Fig. 31 is shown a section taken through the air cylinder and valve chest of a belt-driven two-stage compressor, the arrangement for the two stages being the now not unusual one of a differential trunk piston working single acting. The portion of larger diameter forms the low-pressure piston, and the annular area between the smaller part of the piston and the larger part goes to form the high-pressure piston. The mode of action of the valves will be apparent from an inspection of Fig. 31, and also of the view, Fig. 29, in which the valves are shown more in detail. This view does not necessarily belong to the compressor illustrated by Fig. 31, but represents Alley and MacLellan's typical valve arrangement. Here, besides the piston valves and the delivery spring valves, the section is taken through the inlet passage leading to the low-pressure end of the cylinder. It will be seen that after passing through a screen which is intended to free it from dust and any small particles which may happen to be in the air, the air has to pass through an equilibrium valve, the extent

of whose opening is under the control of the air regulator. The action of this regulator is not difficult to follow. When the demand for air ceases or becomes smaller, the pressure in the receiver rises. This pressure is communicated through the pipe shown to the underside of a copper diaphragm, which is pressed down by the spring, whose length and, therefore, load can be regulated. When the pressure of the receiver air is sufficient to lift the diaphragm, it also lifts a small valve which opens a communication from the receiver to the underside of the controller piston. This lifts the controller piston and closes the equilibrium valve, so that the compressor is now working against a partial vacuum, and is doing no useful work, a small amount being wasted in overcoming the friction of the moving parts of the compressor. Compressors of this type are built for either belt, motor, or steam driving, as may be required. They are found to be very suitable, and have been supplied to many shop and bridge builders where compressed air is wanted to work pneumatic tools. The machine shown in Fig. 30 is of this kind, and has a capacity of 600 cubic feet of free air per minute. Fig. 33 is a section of a larger type of compressor, with double acting high and low-pressure air cylinders, and driven by steam, and Fig. 32 is reproduced from a photograph of a compressor of this type, having capacity from 1200 to 2000 cubic feet, and working up to 100 lb. per square inch. Fig. 34 represents one of three supplied to the Admiralty, having capacities of 2000 cubic feet. By the arrangement of the combined mechanical and automatic type, with piston valve to control the air inlet and the multiple poppet valves to actuate the discharge, the makers of this compressor contend that the old trouble of broken valves, which has been so common with the flat disc type, is entirely done away with, and at the same time a high volumetric efficiency is attained.

The complete cylinders and covers are water jacketed. In the case of the single-crank machines the intercooler is situated in the base plate, and in the double or triple crank machines it is carried at the back of the cylinders on brackets. As these compressors are generally of the enclosed type, no dirt or grit can reach any of the bearings, and in this way possible stoppages owing to heating are avoided. The lubrication throughout is forced from an oil pump driven from one end of the shaft. A filter is fitted between the pump and the crank case in such a way that it can be cleaned out at a moment's notice, even whilst the machine is running. By this arrangement these compressors are able to run for long periods without attention of any kind.

A general view of a pair of air compressors made by the Ingersoll-Rand Company, and working at the collieries of the Cowpen Coal Company, Blyth, is given in Fig. 35. It will be seen that the compressor is of large capacity. It is steam driven by a cross-compound non-condensing engine, with cylinders 26in. and 40in. diameter respectively for the high and low-pressure cylinders, and having a common stroke of 48in. The high and low-pressure air cylinders have diameters respectively of 24¼in. and 38¼in., and the same common stroke of 48in. The valve gear on the steam cylinders is of the Corliss type, and is designed on the assumption that the working pressure of the steam will not exceed 100 lb. per square inch.

As the compression is in two stages an intercooler is provided; its diameter is 54in., and height 15ft. 6in. This receiver-intercooler is provided with a nest of tinned brass tubes, through which the cooling water is circulated. The extent of the cooling surface is supposed to be sufficient to cool the air to the temperature of the atmosphere between leaving the low-pressure and arriving at the high-pressure cylinder.

The inlet or suction valves on the air cylinders are of the usual piston inlet type made by this firm, and are guaranteed for five years against breakage. The delivery valves are of the Ingersoll-Sergeant automatic type, controlled by light springs. The maximum pressure of the air in the delivery pipes is 80 lb. per square inch. The piston displacement of this compressor is 4072 cubic feet per minute. The indicated horse-power developed is 640, the cut-off taking place at 35 per cent. of the stroke, and the consumption of steam at this horse-power is about 21 lb. per indicated horse-power per hour.

A similar machine, but of smaller size, is working at the collieries of the Wearmouth Coal Company, Monkwearmouth, Sunderland. It is also of the two-stage compression type, with air cylinders of 16½in. and 25½in. diameter respectively, and steam cylinders of 18in. and 30in., with a common stroke of 24in. The maximum air pressure may vary from 80 lb. to 100 lb. per square inch, and the initial steam pressure is 100 lb. per square inch.

It should, perhaps, be pointed out that in the piston inlet valves used by this firm the suction air is drawn in through a hollow tail-rod connected to and opening to the interior of the low-pressure piston. From this hollow piston open valves, one to the front and the other to the back of the piston. These valves are annular and concentric with the piston-rod. They are made of steel, are very light, so as readily to respond to changes of pressure, and are without springs.

The different parts are clearly shown in Fig. 36, which is a section taken through the low-pressure cylinder of the Ingersoll-Rand compressors illustrated by Fig. 35. At the left-hand end is the piston-rod, and in line with this, at the right-hand end of the cylinder, is the hollow rod through which the suction air is drawn. This hollow rod is marked A. Suppose the piston to be moving from right to left, the air passes from the outer air, through the hollow rod, to the space B inside the piston. The movement of the piston towards the left causes a partial vacuum at the right of the piston, which is filled by the suction air passing through the annular suction valve C C. At the same time the compressed air at the other end of the cylinder is being discharged through the delivery valves in the cover at that end. At the beginning of the return stroke the change of pressure will close the suction valve C C, and open that on the other side of the piston D D. The section in this case happens to have missed all the delivery valves but one, which will be seen at the lower side of the back cover. This is a light spring-controlled disc valve, and opens into the discharge chamber F.

Fig. 37 gives a sectional view of an Ingersoll air receiver and cooler. This consists of a nest of thin brass tubes contained in an inner cylinder. Water is made to pass upwards through these tubes, and at the same time the warm air enters at the top of the casing and passes downwards between and around them. After passing the tubes the air leaves the inner casing and enters the interior of the outer casing. This serves as the receiver, from which the air is taken for use, or to the high-pressure cylinder when the receiver is acting as an intercooler.

The Riedler compressor is historically interesting as representing what was probably the first successful attempt to design an economical compressor on scientific lines. One of the best known and largest installations designed by Professor Riedler is that built for the purpose of supplying the city of Paris with a compressed air supply. The main principle involved in the design is one which has been adopted in many later compressors by other makers—namely, the employment of valves controlled by weak springs or air cushions, in which the work usually performed by strong springs in automatic compressors is in this case done mechanically by a movement derived from the mechanism of the compressor

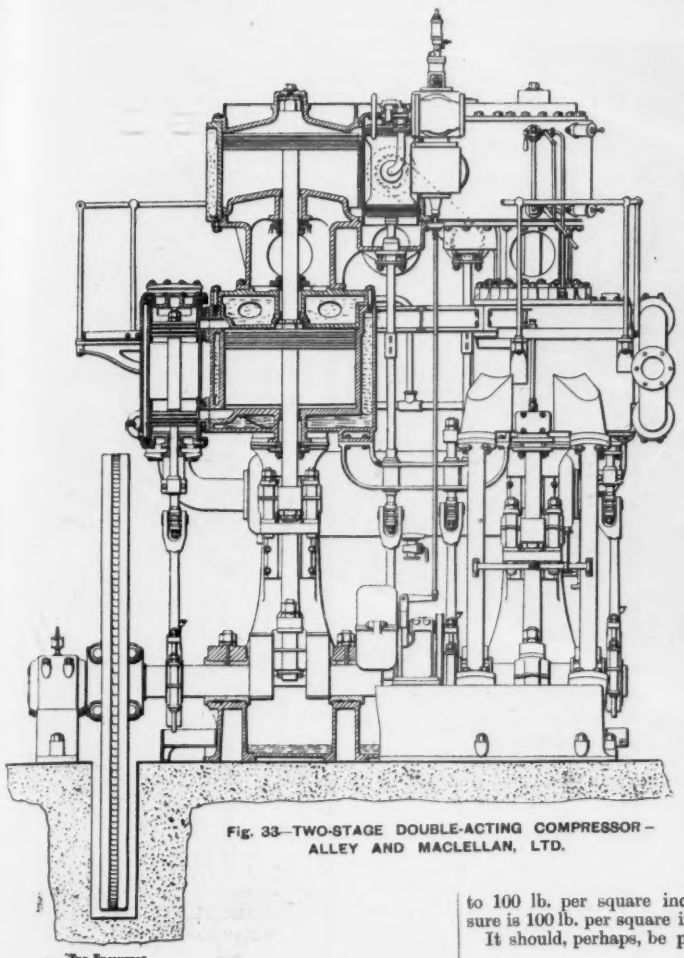


Fig. 33—TWO-STAGE DOUBLE-ACTING COMPRESSOR—ALLEY AND MACLELLAN, LTD.

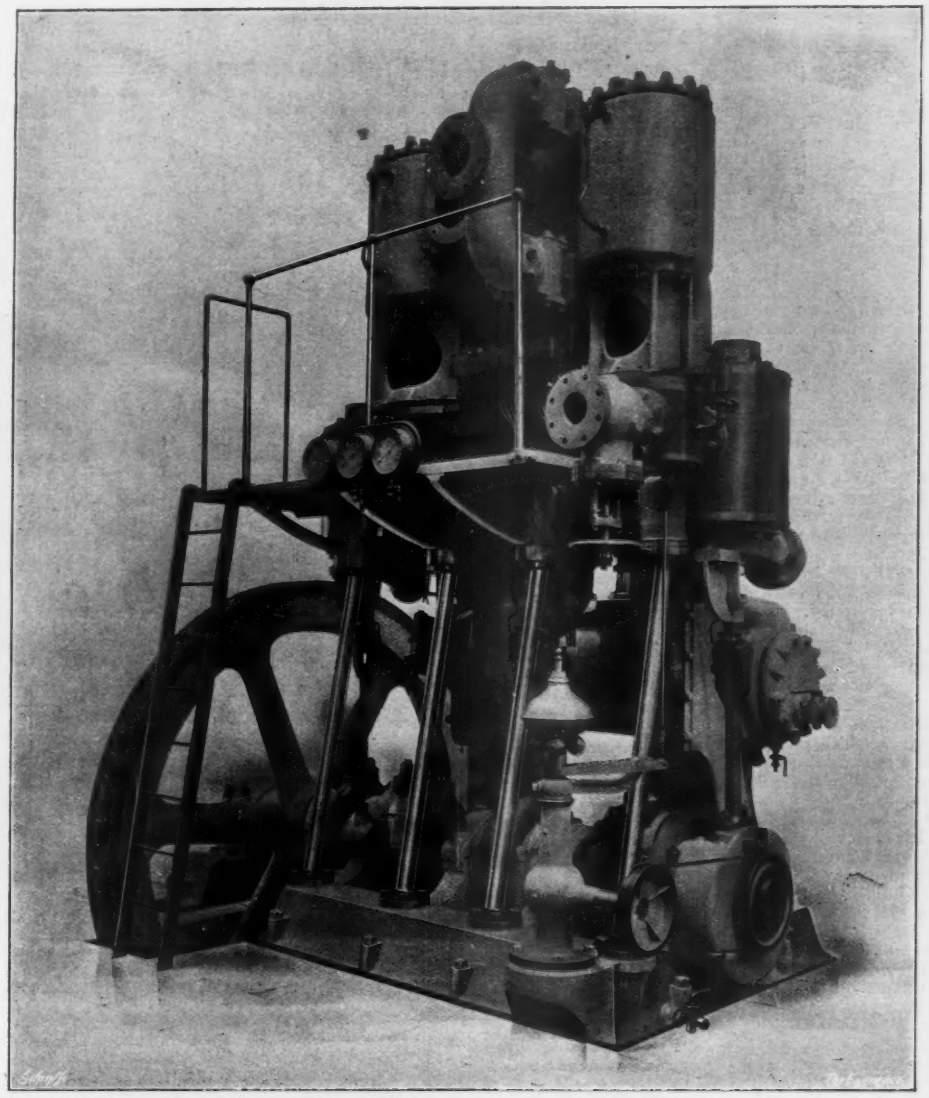


Fig. 34—2000 CUBIC FEET VERTICAL COMPRESSOR, ADMIRALTY TYPE—ALLEY AND MACLELLAN, LTD

The views, Figs. 39 and 40, represent a two-stage Riedler compressor, recently built for the Consolidated Goldfields of South Africa by Fraser and Chalmers, of Erith. This is a compressor of large capacity, and is driven by a compound steam engine whose cylinders are 24in. and 43in. diameter; and the air cylinders are 25in. and 41in. diameter, all four cylinders having a common stroke of 54in. The air cylinders are arranged in the usual way, tandem fashion behind the steam cylinders. The steam pressure used is 135 lb. at the throttle valve, and the compressor is guaranteed to compress 5000 cubic feet of free air per minute to a gauge pressure of 80 lb. per square inch when running at 65 revolutions per minute. The compressor is situated at a height of approximately 5000ft. above sea level. It is running condensing, with an assumed vacuum of 20in. In addition to the dimensions already given, some further particulars of the steam engine part will now be added.

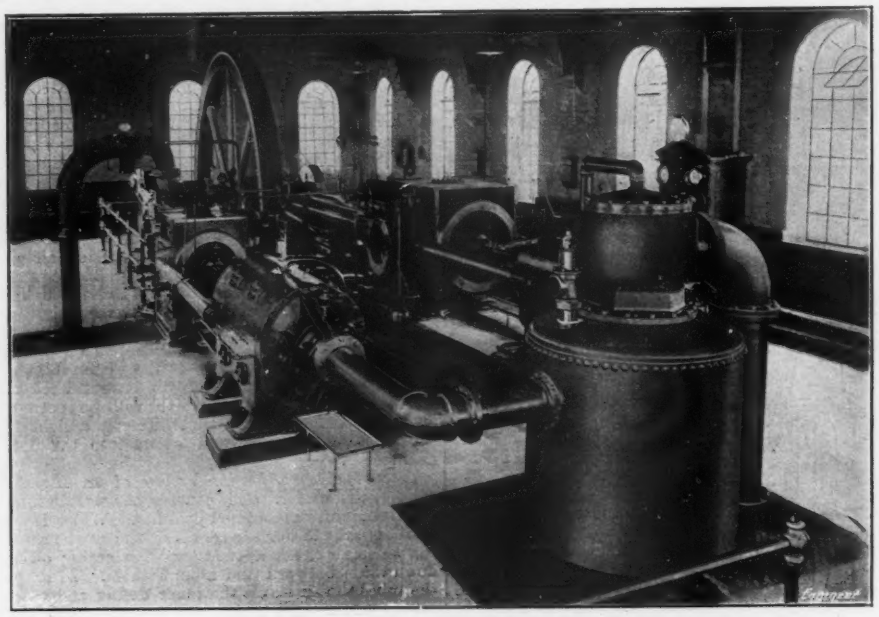


Fig. 35—TWO-STAGE COMPRESSOR—INGERSOLL RAND CO.

The steam cylinders are jacketed, cast iron liners being forced into the barrels and caulked with copper rings at each end. The valve chests are cast in the cylinder body, the steam admission valves being situated at the top, while the exhaust valves are at the bottom of the cylinders. The valve gear is of the type known as the Reynolds-Corliss. The point of cut-off on the steam valves, which also acts as relief valves, is under the control of Fraser and Chalmers' patented Whitmore combined speed and air governor. The valve arms and trip gear for this motion are made entirely of cast steel fitted with hardened steel pins. The steam pistons are provided with a broad ring of Babbitt metal of a special mixture, which, owing to the large amount of graphite, has a good lubricating effect, and a very good surface is maintained in the cylinder. Between the high and low-pressure cylinders the steam passes through a receiver, which, being fitted with a heating coil, is also a reheater.

The object of the air and speed governor is to make the speed dependent upon the amount of air required. The governing is such that if the compressor is running at its full capacity and speed, and the air is suddenly released, the speed will not exceed the normal maximum by more than five revolutions. The governor is also designed to run at a minimum speed when all rock drills are shut off.

The dimensions of the air cylinders have already been given. The valve chambers or heads of these cylinders are bolted to the barrel, and in each head there are two suction and two delivery valves of the Riedler type. The gear for operating these valves is all mounted on the outside of the heads, where it can be inspected and adjusted with the minimum amount of trouble.

In the Riedler valve gear, whose design is fairly well known, the movement of the valves does not depend upon springs, but the valves open automatically without resistance, while the closing is effected mechanically, the speed gradually diminishing to zero as the valves touch the seats, so that there is little possibility of the valves or the seats wearing. The closing gear is worked from a wrist-plate in a manner not unlike that of the Corliss gear. The slowing down of the valves as they come upon their seats is brought about by means of an air cushion. The makers contend that, owing to this arrangement of valves opening automatically with little resistance and closing mechanically with the help of an air cushion, these compressors may be run without damage at much higher speeds than is usually the case with compressors of similar size. Both suction and delivery valves are made of forged steel turned out from the solid and machined exactly to standard; they are made as light as is possible consistent with strength. The seats of these valves are of hard cast iron, and are fixed in the cylinder heads in such a manner that they can readily be inspected or removed in a few minutes. The air cushions are provided with adjusting screws, so that the speed of closing can be regulated. The stems and spindles of the valves are also of steel mounted in cast iron bearings.

The gear for closing the air valves consists of a cam case-hardened and ground, fitted on a wrist plate on the cylinder. It closes the air valves by means of rollers in connection with the cams. These rollers are also case-hardened and ground, and are mounted on two independent levers carried on fulcrum pins, which are secured on bosses cast on the wrist plate bracket. The wrist plate of the air cylinder is coupled, through the medium of a rocker arm, to the exhaust wrist plate on the steam cylinder, and from thence to an excentric on the engine crank shaft. All the cylinders are mounted on heavy cast iron sole plates, which are tongued and grooved so as to keep them exactly in line when the engine expands

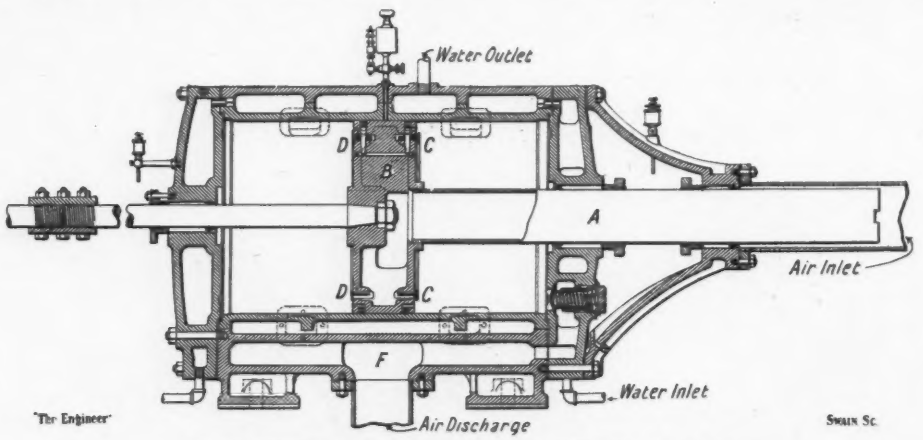


Fig. 36—SECTION THROUGH AIR CYLINDER—INGERSOLL RAND CO.

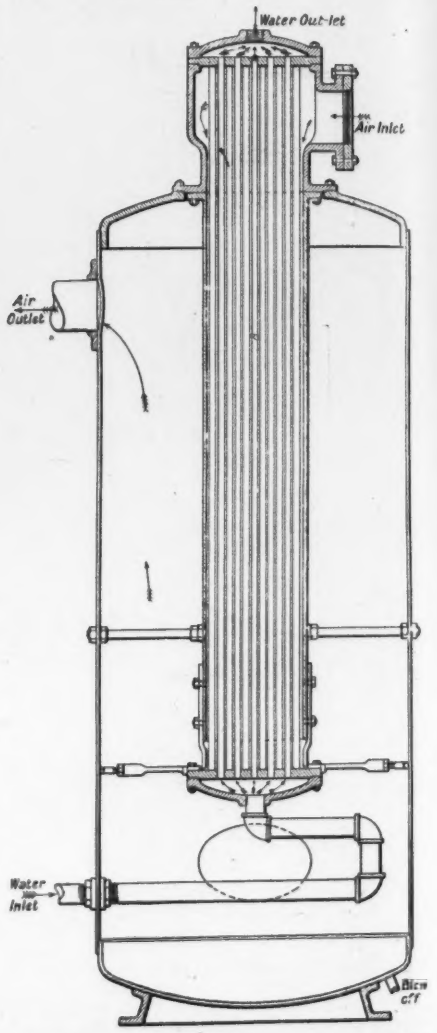


Fig. 37.—RECEIVER INTER-COOLER—INGERSOLL RAND CO.

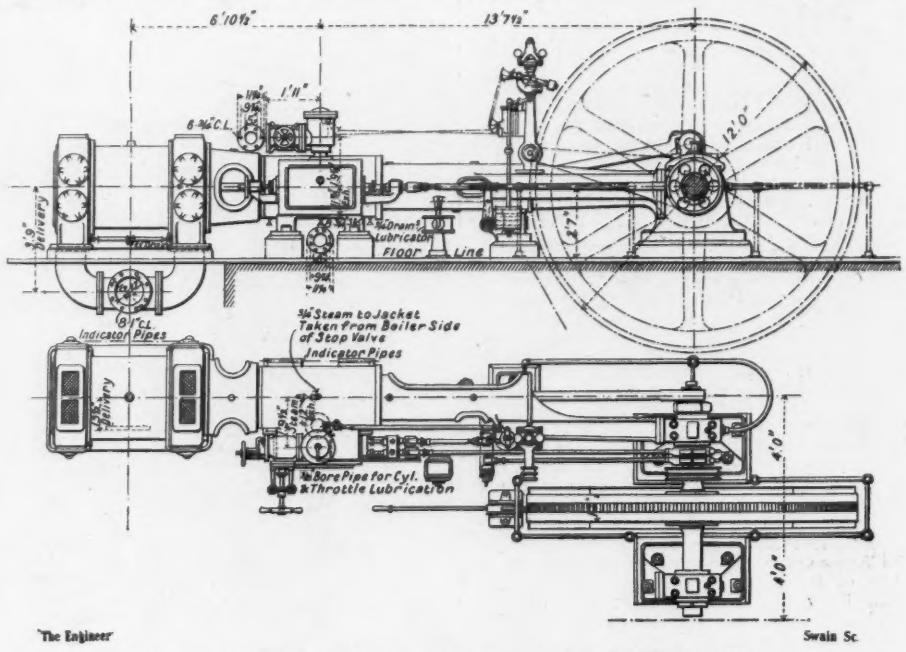


Fig. 38—GUTERMUTH BLOWING ENGINE—FRASER AND CHALMERS, LTD.

under a raised temperature. In addition to the air and steam cylinders being bolted to the same bed-plate, the air cylinders are tied to the steam cylinders by means of heavy polished tie-rods.

Between the low-pressure and the high-pressure air cylinders is the intercooler. This consists of a boiler plate shell and brass tubes expanded into wrought iron tube plates, and fitted with ferrules. For this particular compressor the cooling surface in the intercooler amounts to about 2300 square feet. The air passes round the outside of these tubes, and the cooling water passes through them. A relief valve is provided on the pipe to prevent high pressure in the low-pressure air cylinder. A water trap is placed between the water cooler and the high-pressure air cylinder, the cooler requiring about 240 gallons of cooling water per minute, at a temperature of 65 deg. Fah., to cool the air coming from the low-pressure cylinder to a temperature of 70 deg.

A barring engine is supplied, and is sufficiently powerful to turn the main engine over when there is full air pressure in the cylinders.

The lubrication of the main bearings is continuous, and is effected by independent oil pumps.

The fly-wheel is of cast iron, weighing about 23 tons, and having a diameter of 26ft. It is built in four sections.

Although not strictly within the scope of this supplement, we show in Figs. 38 and 41 a blowing engine made by Fraser and Chalmers, in order to illustrate the use of a peculiar type of air valve. It will be seen that there is a steam cylinder and an air cylinder placed in tandem. The diameters of the steam and air cylinders respectively are 16in. and 33in., with a common stroke of 36in. This machine has a capacity of 2850 cubic feet of free air per minute, raised in pressure to 13 lb. per square inch, when running at a speed of 85 revolutions per minute. The steam cylinder is fitted with the usual Myer adjustable cut-off gear. The valves on the air cylinder are of the Gutermuth type. They are made of bronze sheets, the metal used being the special mixture known as Tombak metal. The flap of the valve is thickened for strength, while the thinner part is rolled into a spring. The action of these valves is analogous to that of the hairspring of a

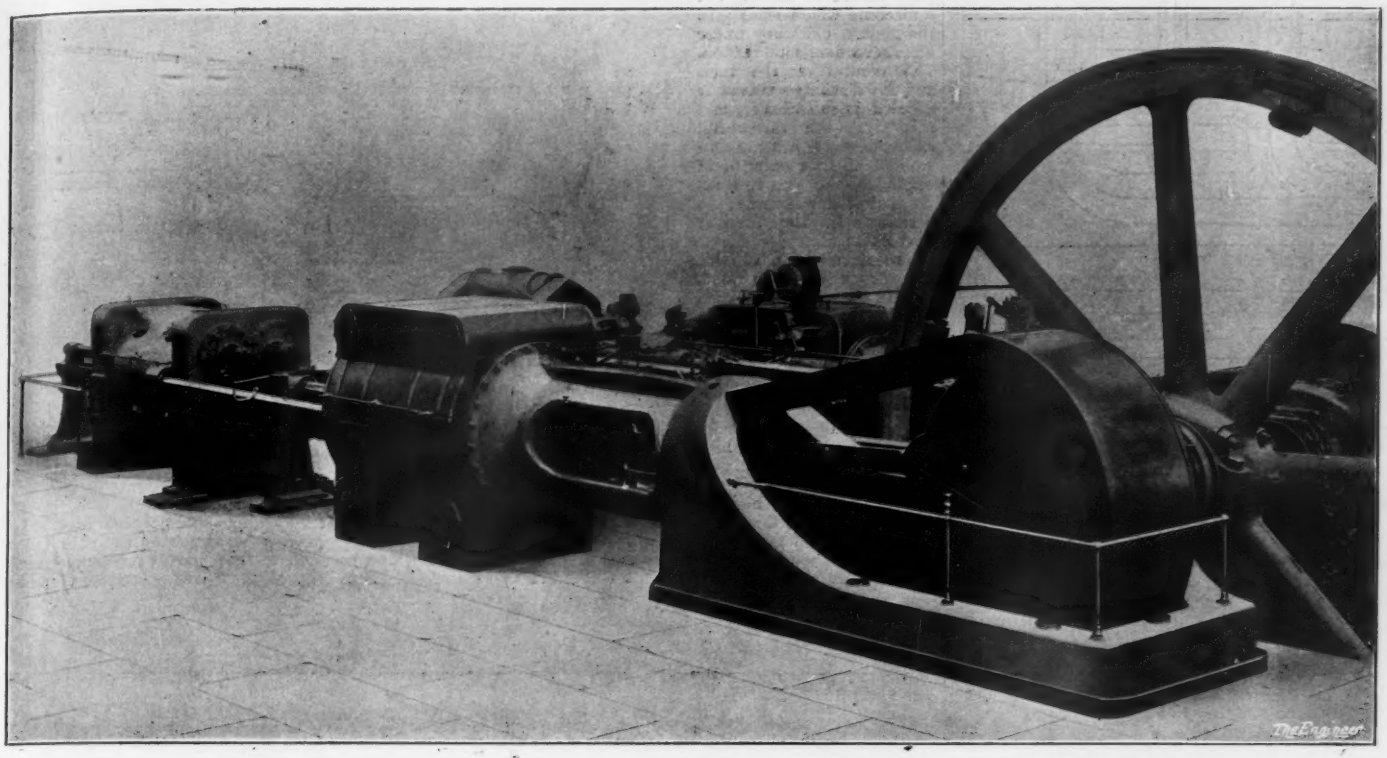


Fig. 39—TWO-STAGE STEAM-DRIVEN RIEDLER COMPRESSOR—FRASER AND CHALMERS, LTD.

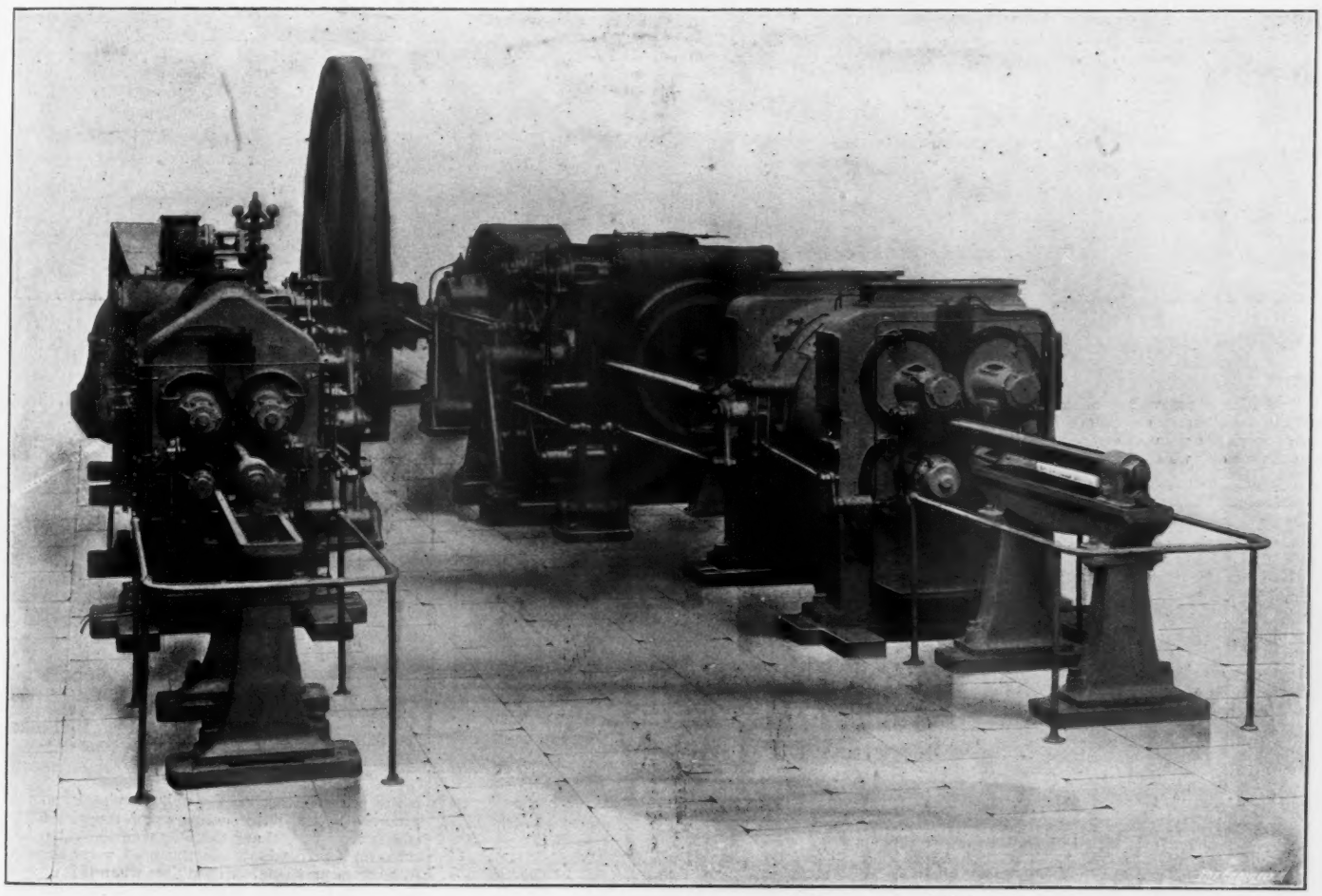


Fig. 40—TWO-STAGE STEAM-DRIVEN RIEDLER COMPRESSOR—FRASER AND CHALMERS, LTD.

watch; the weight of the single moving part being very small, the valve offers very little resistance to the flow of the air, and opens and closes very rapidly without noise.

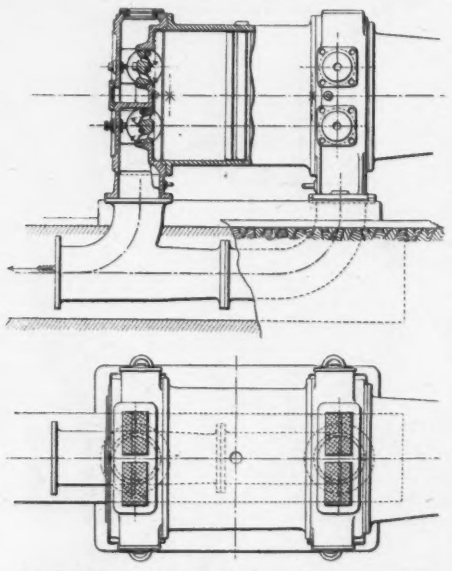


Fig. 41—COMPRESSOR WITH GUTEFMUTH VALVES

The valves themselves are carried in cast iron cylindrical seats fitted into each cylindrical head, two for the suction and two for the delivery. The seats may easily be taken out for inspection or renewal by removing a single cover. All suction and delivery valves are interchangeable so that only one size of spare valves need be kept in hand.

The compressors which have been described so far have either been fitted with valves, which are purely automatic in their action, or the valves have been made dependent, either in part or entirely on positive mechanical movements derived from the motion of the piston. The "Daw" compressor, designed by A. and Z. Daw, of London, and built by Robey and Co., Ltd., of Lincoln, represents a new type, in so far that the movement of its valves is placed under pneumatic control. In the design of this compressor A. and Z. Daw have aimed at turning out a machine which shall give the highest efficiency under all conditions of compression. The control of the inlet and the discharge valves is effected pneumatically, and this gives the valves full automatic action with control of their opening and closing at the proper time, no matter how greatly the pressures in the receiver may fluctuate.

The introduction of this compressor has been rapid, Fig. 42 shows one of several 200 horse-power compound two-stage compressors which have been built. The capacity of this machine is 1250 cubic feet of free air per minute, the cylinders being 20½in. and 13in. in diameter for low pressure and high pressure respectively, with a stroke of 30in. The speed of running is high for a compressor of this size, being 110 revolutions per minute, equivalent to a piston speed of 550ft. per minute. The maximum air pressure is 80 lb. per square inch gauge. A vertical intercooler is placed between the low-pressure and high-pressure cylinders. This is designed with a sufficient capacity to act as a receiver. A view of this is shown in Fig. 43. This cools the air to within 10 deg. of the temperature of the cooling water. Of course the cylinders are fully water jacketed.

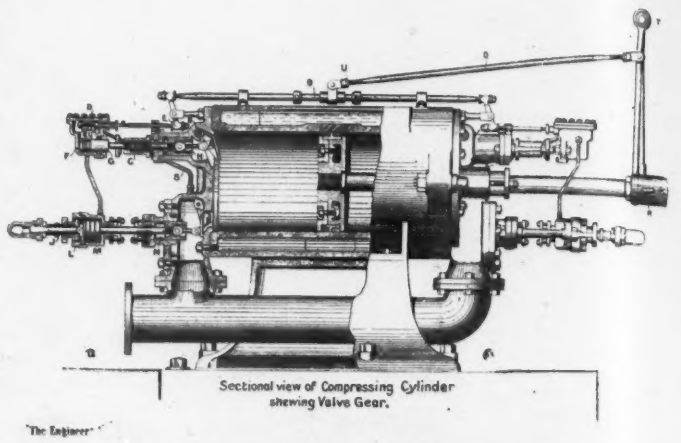


Fig. 45—SECTION OF AIR COMPRESSOR—A. AND Z. DAW

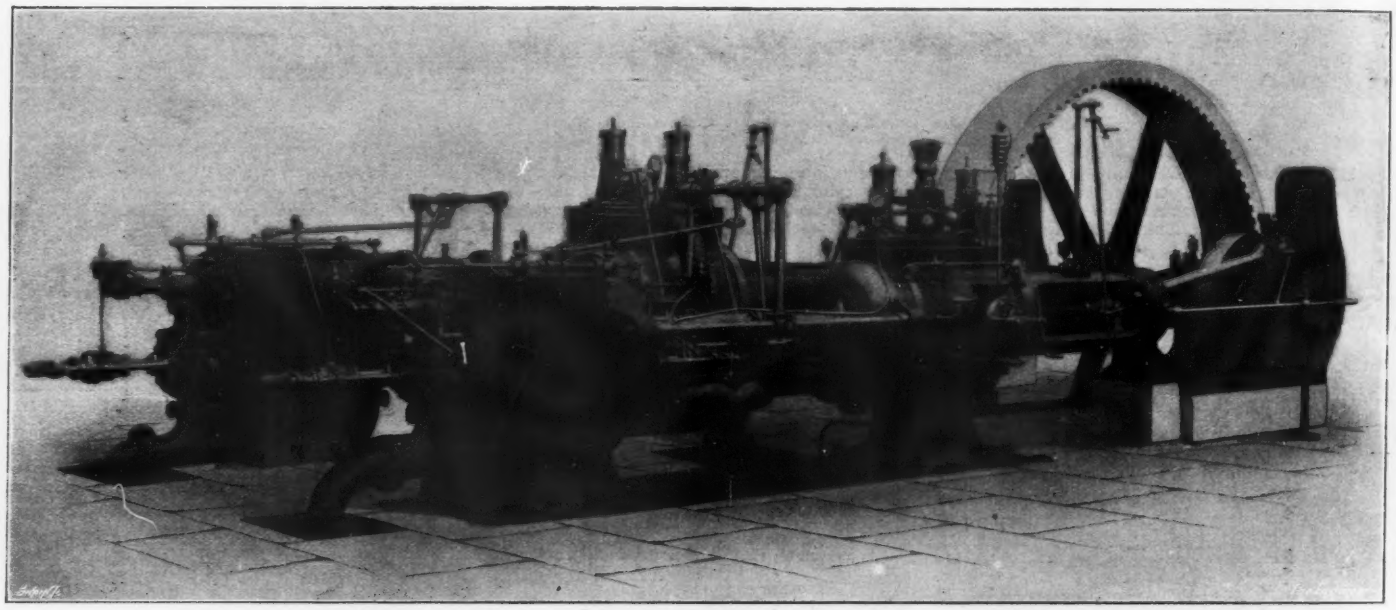


Fig. 42—200 H.P. TWO-STAGE COMPRESSOR—A. AND Z. DAW

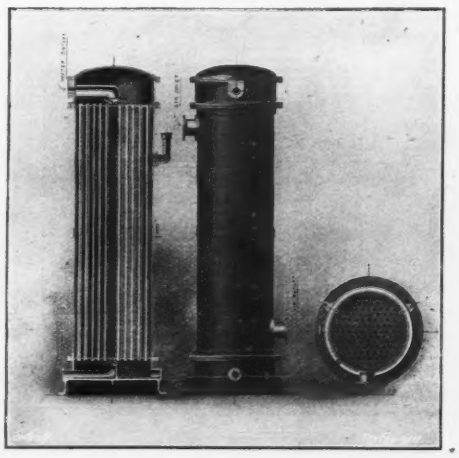


Fig. 43—INTERCOOLER—A. AND Z. DAW

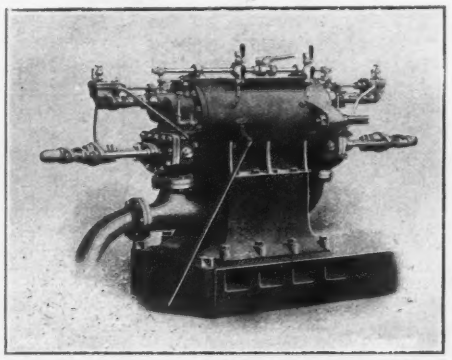


Fig. 44—AIR CYLINDER AND VALVE GEAR—A. & Z. DAW

The steam cylinders have drop valve gear to give the best distribution of steam under all loads with the minimum steam consumption. The high-pressure steam cylinder is 12in. diameter, and the low-pressure cylinder 24in. diameter, with a common stroke of 30in. The initial pressure of steam at which this engine works is 120 lb. per square inch. With the idea of keeping, as far as possible, the steam consumption proportional to the compressed air required, the speed of the compressor is automatically regulated by a pressure regulator. This acts in conjunction with a speed governor attached to the steam valve gear, so as to control the cut-off mechanism, and so regulate the speed of the compressor. By reference to Fig. 45, in which a section of a double-acting "Daw" compressing cylinder is shown, the action of the air valve gear should be understood. Here the inlet valve A is placed in the cylinder cover, and is seen in its open position, pivoted at B and opening inwards. The tendency for this valve to be kept closed is maintained by the air pressure within the compressing cylinder and also the strong spring C.

The small slide valve D is actuated by the valve gear E, and, at the commencement of the suction stroke, places the rear end of the small cylinder F in communication with the receiver through the pipe S; so that the pressure in the latter, acting upon the piston G, overcomes the spring C and the weight of the valve A. This pressure is maintained, and the inlet valve thereby kept in its open position, from the time when it is opened and during the full length of the suction stroke. In this way the cylinder is filled with free air at the pressure of the atmosphere, and this conduces to a high volumetric efficiency.

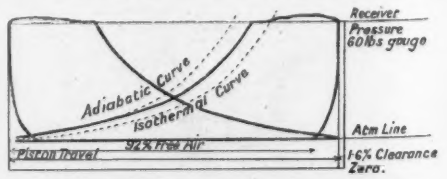


Fig. 46.—AIR CARD FROM DAW COMPRESSOR

The pressure set up on the inlet valve piston G, at the commencement of the suction stroke, is sufficient to ensure the inlet valve A opening instantly, and the practice being to make the area of the inlet valve as large as circumstances will permit, there is, conse-

TWO STEAM-DRIVEN COMPRESSORS

(For description see page xv.)

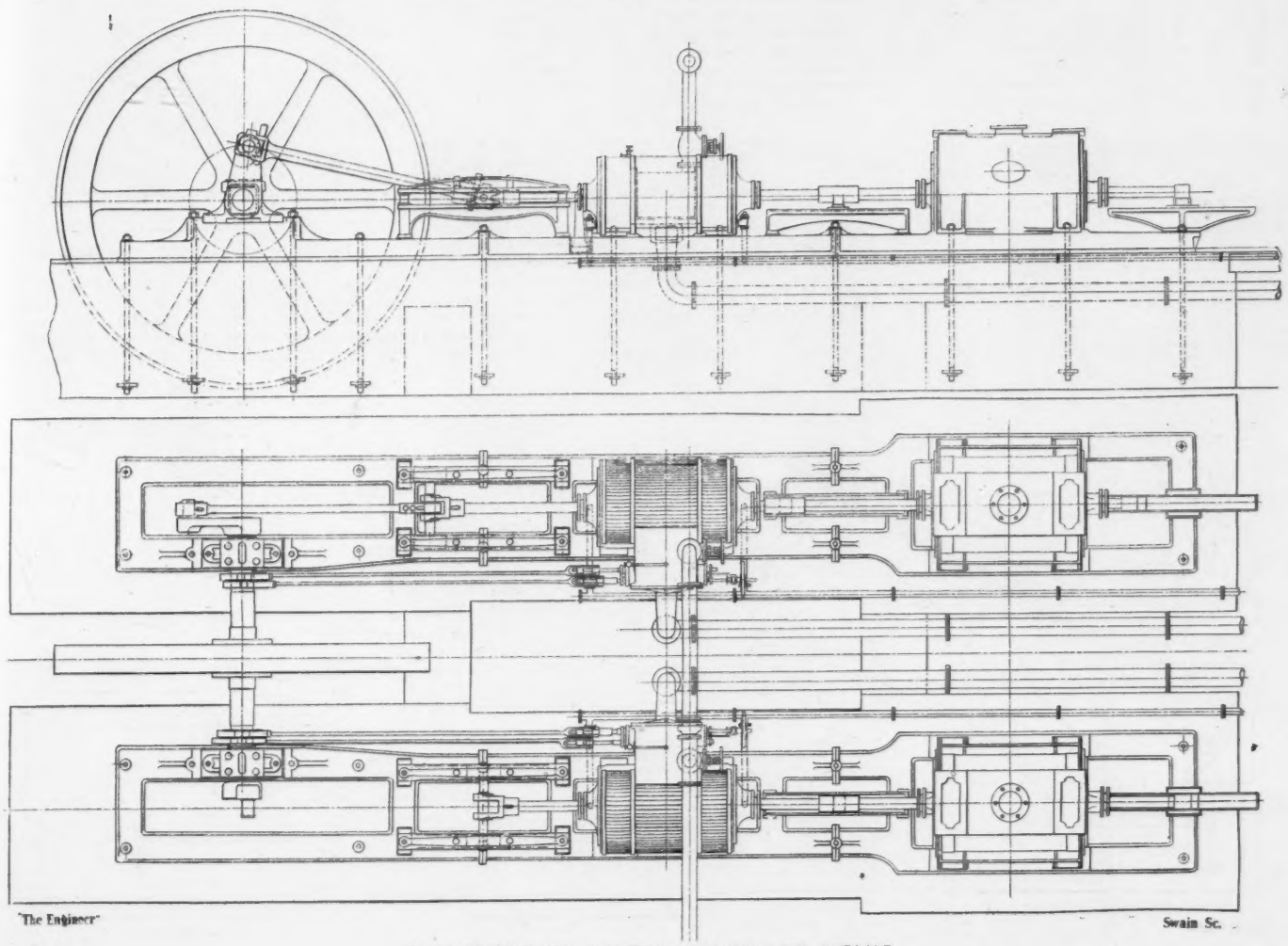


Fig. 47—STEAM-DRIVEN COMPRESSOR—CARRICK AND WARDALE

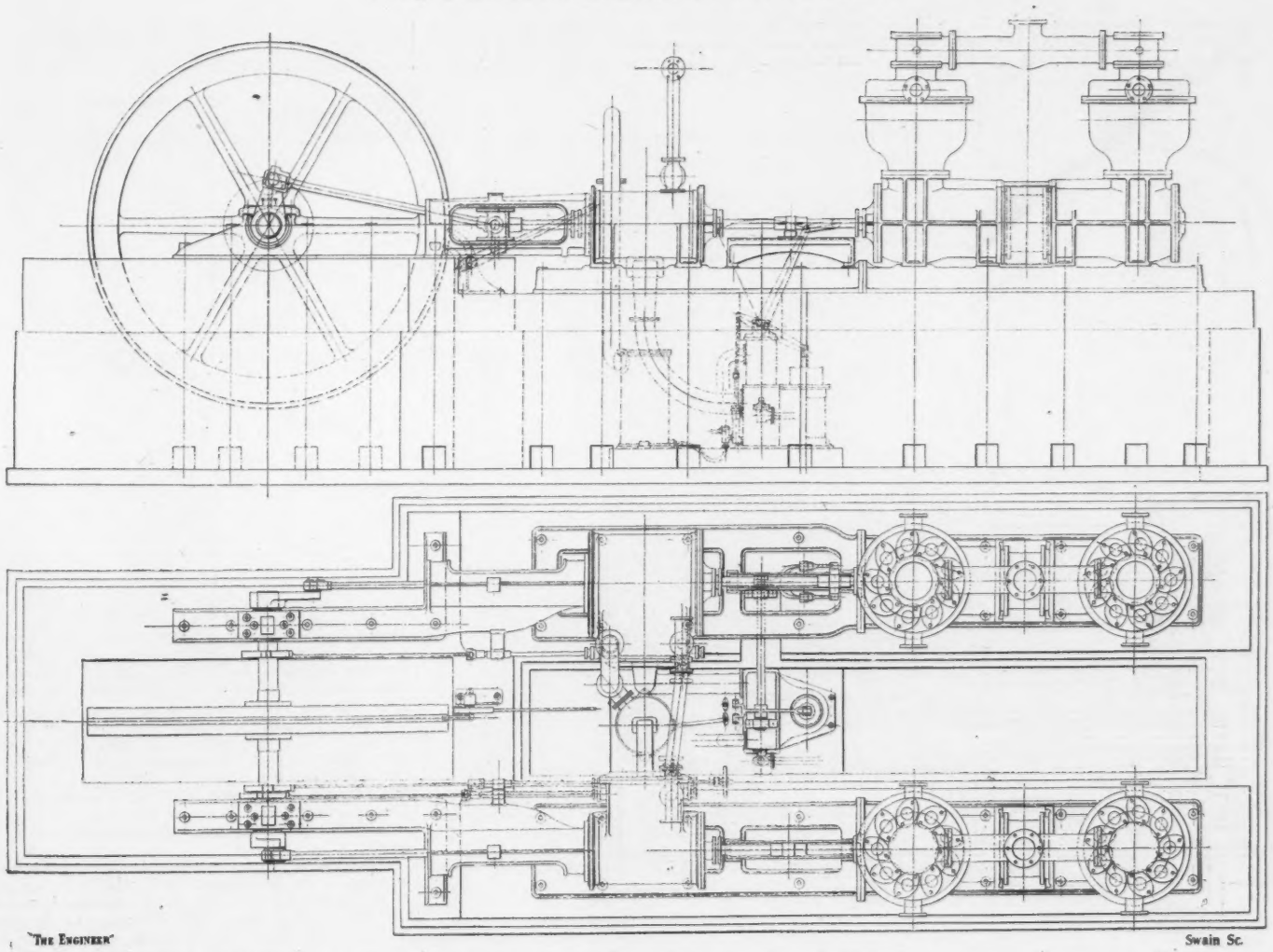


Fig. 48—CROSS-COMPOUND COMPRESSOR—CARRICK AND WARDALE

quently, no obstruction to or wire-drawing of the air during admission; and the cylinder is filled with air at the full pressure of the atmosphere, thus doing away with one cause of the loss of efficiency.

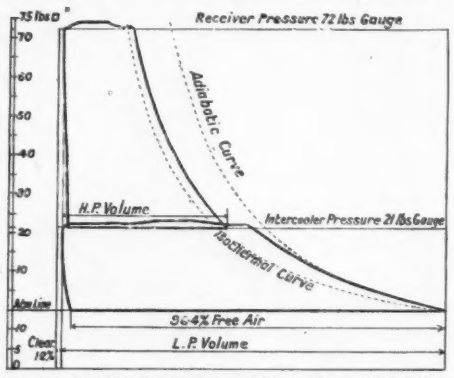


Fig. 49—COMBINED CARDS FROM DAW COMPRESSOR

At the completion of the suction stroke the small slide valve D is reversed to exhaust, and the spring C being thus relieved of the pressure acting against it, closes the valve. The small cylinders F and H act as dashpots or buffers, and ensure the valve closing quietly and without shock. The pressure set up on the inlet valve control piston G, at the commencement of the suction stroke, is sufficient to ensure the inlet valve A opening instantly, and the removal of the pressure causes the equally ready closing of the valve by the spring C.

The air enters the cylinder with the least possible contact with hot surfaces, and before and during compression its temperature is raised as little above that of the outside temperature as is possible; and it should be noted that an avoidable rise in temperature of 5 deg. Fah. may result in a loss of 1 per cent. in the work required to compress the air, and this will be accompanied by a corresponding reduction in the capacity of the plant.

The delivery valve is shown in its closed position, the spring J, the pressure of the air in the receiver, and the weight of the valve itself, all tending to keep it closed. It is pivoted in a similar way to the inlet valve, and is arranged to open outwards relatively to the compressing cylinder. It is enclosed in a casing which is in open communication with the receiver, the pressure of which is always being exerted on the back of the valve.

An opinion which prevails is that as the volume of air when compressed is considerably reduced, delivery valves as compared with suction valves need only have a small opening; but the converse is essential if the compressor is to work with safety and efficiency, because although the volume delivered is less, its density is greater, and it has to be discharged in proportionately less time. In the present compressor, therefore, the discharge valves, as well as the suction valves, have the largest possible area of opening. It is found, the makers claim, that the perfection of the pneumatic control is such that these large valves can be run at speeds quite unobtainable by other means, and the resistance to the passage of the air is reduced to a minimum. The discharge valve K is balanced through the small slide valve D, which is actuated by the valve gear E, placing the front end of the small auxiliary cylinder L in communication with the receiver. The latter pressure, acting upon the piston M, balances the difference in pressure on the discharge valve K, due to the weight of the valve seating, the force of the spring J and the weight of the valve causing the discharge valve to open without any excess of pressure being set up in the compressing cylinder. As the discharge valve lifts off its seat a portion of the balancing pressure in the cylinder L becomes an active force, and opens the valve rapidly and keeps it fully open until the compression stroke is complete. The slide valve D is then reversed by the valve gear, so that the pressure in the cylinder L is exhausted, and the spring J, being thus relieved from the pressure acting upon it, instantly closes the valve. The cylinders L and N act as dashpots, or buffers, and ensure the valve opening and closing quietly and without shock.

If the pressure in the receiver should vary, the time of opening of the discharge valve in relation to the stroke of the piston will vary with the fluctuations in pressure, and this presents insuperable difficulties to the positive movement of the valves by direct mechanical connections. By the pneumatic control used in the "Daw" system, however, positive movement is secured, and

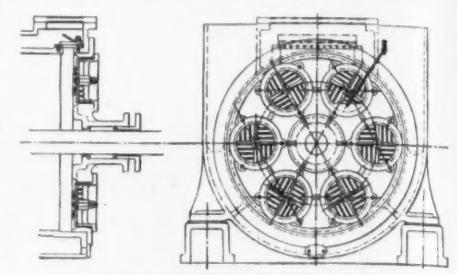


Fig. 52—VALVES—CARRICK AND WARDALE

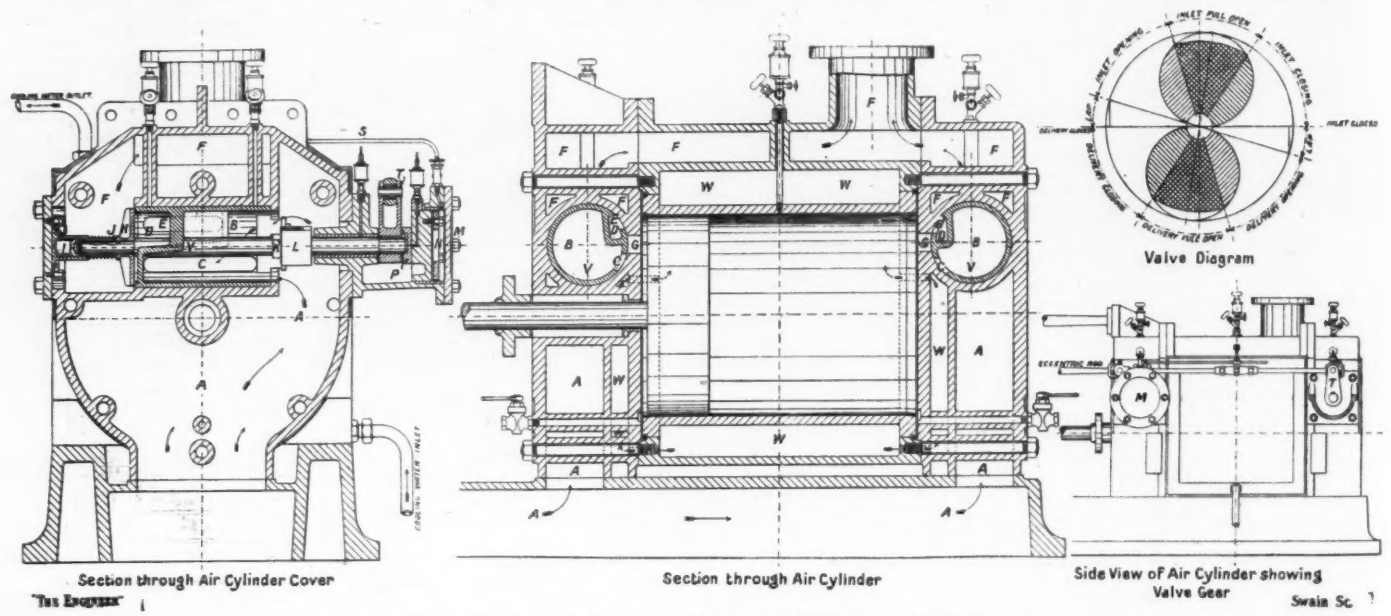


Fig. 50—SECTIONS OF AIR CYLINDERS, &c.—HUGHES AND LANCASTER

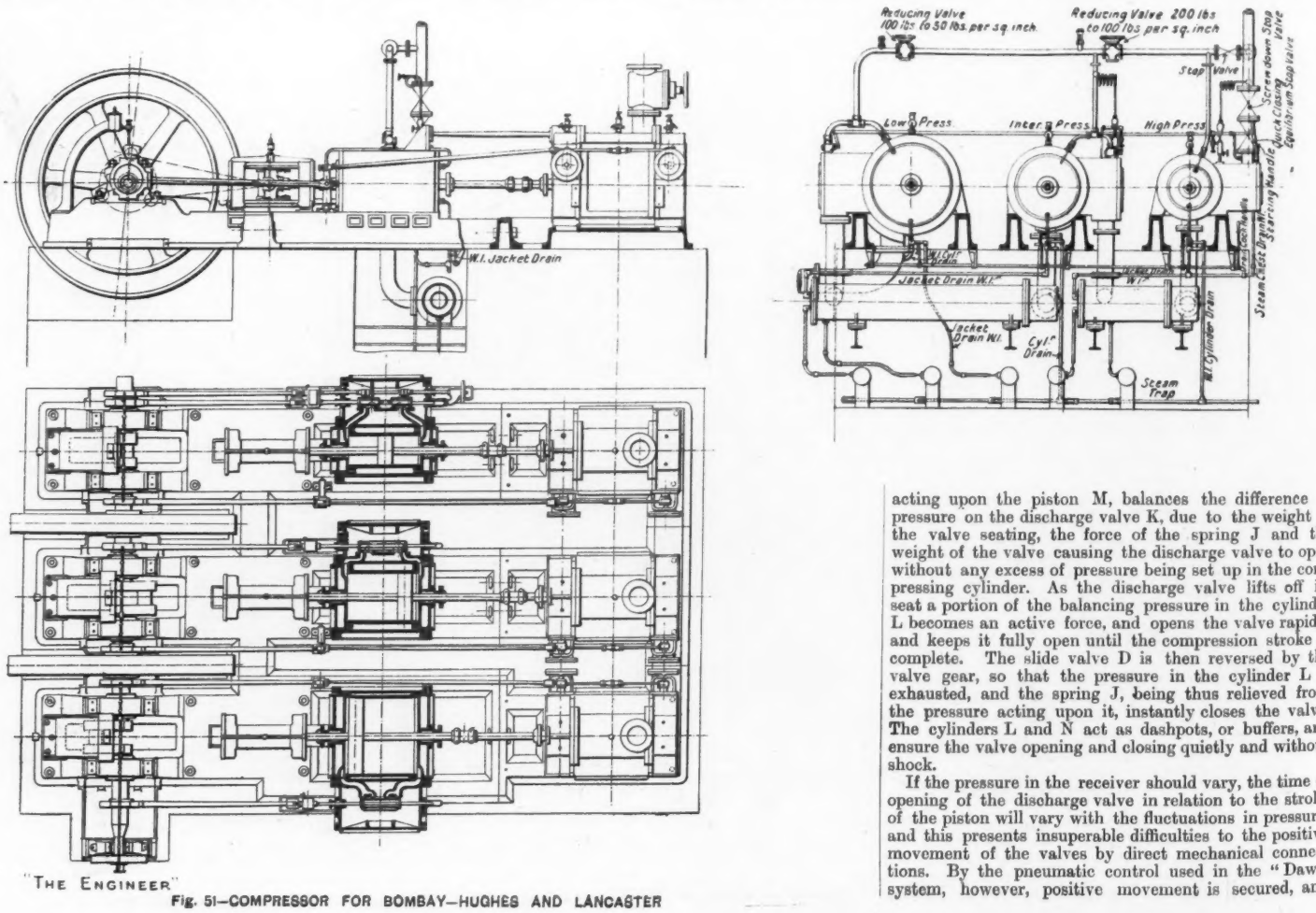


Fig. 51—COMPRESSOR FOR BOMBAY—HUGHES AND LANCASTER

the discharge valve opens at the moment the receiver pressure is reached, is held open during discharge, and closes instantly after the discharge of the compressed air, under all conditions of speed and pressure. On the contrary, an essential condition of valves which are mechanically operated, and not controlled pneumatically, is that the delivery port must be closed gradually towards the end of the stroke, thus necessitating the

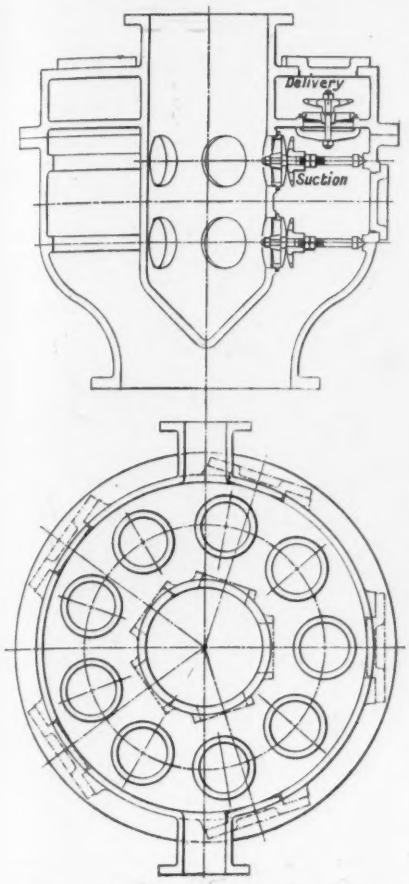


Fig. 53—VALVE BOX—CARRICK AND WARDALE

forcing of the air through the port with a gradually increasing velocity, and there results from this an excess of pressure and a great rise in the temperature of the air discharged. The designers of the "Daw" compressor contend that this serious defect, to which they think many explosions in compressors have possibly been due, is obviated by

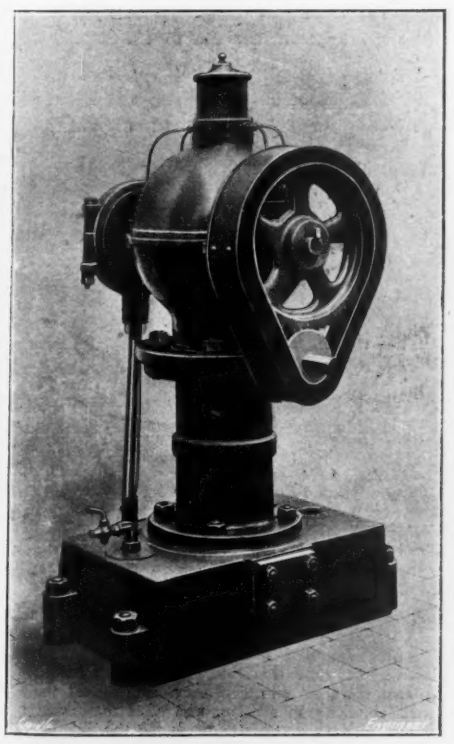


Fig. 54.—VERTICAL COMPRESSOR—HUGHES AND LANCASTER

their system of valve control, which ensures that the valve is kept full open until the whole of the compressed air has been delivered. In addition to this, although closing gradually at the end of the stroke, the pneumatic gear admits of the discharge valve lifting freely off its seat should the pressure from any cause be excessive during the closing period, and, further, that the pneumatic control makes the valve self-adjusting for all speeds and pressures.

With an unbalanced valve there must be a rise in pressure in the compressing cylinder over the receiver pressure in order to balance the extra load on the receiver side of the valve. This is due to difference in the area of the surface of the valve exposed to the receiver pressure and that exposed to the pressure in the cylinder caused by the valve seating. This excess of pressure in the cylinder will vary with the size of valve and width of seating, but probably never falls below 15 lb. per square inch. In addition to causing extra stress on the engine

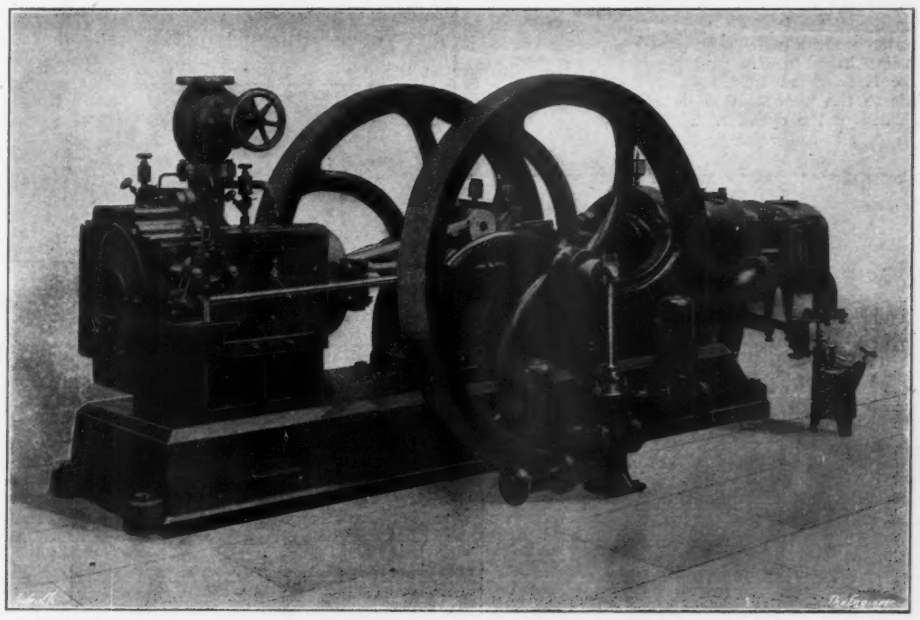


Fig. 55.—COMPRESSOR AND OIL ENGINE—HUGHES AND LANCASTER

there will be a loss of work of about 1½ per cent. at least, and with small valves it may be very much greater.

In order to minimise this effect of excess pressure during compression valve seatings are often cut down to the smallest possible width. After being used for a short time this leads to possibility of leakage back again into the cylinder of the air which has been compressed, but with a balanced valve there is no need to cut down the seat area.

It has been pointed out that a small slide valve D controls the small pistons which actuate the inlet and delivery valves. Its movement is effected in the following way:—A short rod R is connected to the piston-rod and actuates the long arm of a lever, whose fulcrum T is placed at a distance above it, which is approximately equal to the travel of the piston. Forming part of this lever is a connection nearer to the fulcrum, so as to give a short travel to the rod Q. This has a sliding connection U upon the horizontal rod Q, upon which are fixed adjustable stops, actuating the small slide valve D at the end of each stroke of the compressor, the valves remaining stationary at all other time. By means of this positive motion it is ensured that the valves D will move exactly at the time required, and in this way cause the admission valves to open, and the discharge valves to close in the manner required to give the desired results. Owing to the small diameter of the control cylinders, and the short movement of the piston, the consumption of air by the pneumatic control is very trifling, being barely one-third of 1 per cent. of the air delivered by the compressor.

When the Daw valves are used on blowing engines they are fitted with flat grid slides, so as to give straight through ports, and, consequently, a large opening. This is necessary, as any excess pressure must be avoided, owing to the comparatively large volume of air to be delivered at a low pressure. For example, if the receiver pressure is, say, 7·35 lb. per square inch gauge pressure, and the air is ejected at a pressure of 9 lb., there will be a loss of efficiency of some 20 per cent.

As will be seen from Fig. 44, all the gear for controlling the valve is upon the outside, where it is readily accessible for adjustment and attention.

The indicator diagram, Fig. 46, page xii., will serve to show the nature of the work done by this compressor. This is a test card taken from a single-stage compressor with air cylinder 11in. diameter and 18in. stroke, running at 115 revolutions per minute. Fig. 49 shows combined air cards of a 13in. high-pressure, 20½in. low-pressure compressor with a stroke of 30in. This compressor is, of course, two-stage, and runs normally at 94 revolutions per minute. The test

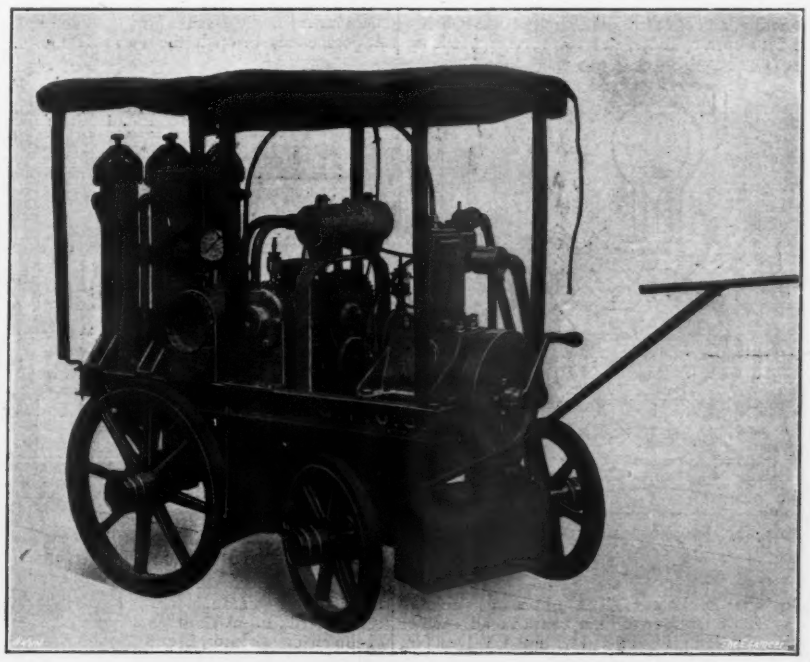


Fig. 56.—PORTABLE COMPRESSOR AND PETROL ENGINE—LACY-HULBERT AND CO., LTD.

gave a volumetric efficiency of 96·4 per cent., which is decidedly good, and the compression line of the cards will be seen to approach very closely to the isothermal line. The slight excess pressure shown on the delivery line of these cards is not due to the valves, but to the resistance in the air passages and pipes.

Compressors for supplying air for use in special chemical processes are made by Carrick and Wardale, of Gateshead. The arrangement shown by Fig. 47 is that of a high-pressure air-compressing engine used for supplying

air and passing it through a neutralised solution of MnO, to oxidise it into MnO_2, in the manufacture of bleaching powder by the Leblanc soda process. In this machine the steam cylinders are 26in. diameter and 48in. stroke. The cylinders are fitted with variable expansion gear, actuated from the outside, and driven by means of separate excentrics, in order to regulate the cut-off according to the varying load on the engines. The air cylinders are arranged to work in one stage, and have diameters of 40in. and a stroke of 48in. Each of these cylinders is double acting, and the cooling is effected by water jackets. Each cover is fitted with six detachable suction valves, as shown on Fig. 52, each 10in. diameter, and designed to have a minimum amount of clearance when the piston is at the end of its stroke. The valves themselves are of india-rubber, and work against wrought iron disc-shaped guards. An arrangement is used whereby water is admitted to the suction valves in order to lubricate the piston. One delivery valve is fitted at each end of the cylinder. These valves are 18in. long

Fig. 57.—COMPRESSOR AND GAS ENGINE—LACY-HULBERT

and 3in. wide, and the air, after passing through them, enters the main air chamber, as shown on the drawing. The fly-wheel is 14ft. diameter, and weighs about 12 tons. It is mounted on a Siemens-Martin steel crank shaft 12in. diameter. The weight of the pistons is partially carried by the motion bars which carry the intermediate and tail rods.

By Fig. 48 is shown an arrangement of a horizontal compound condensing engine used chiefly for compressing CO_2 (carbonic acid gas) for the recovery of ammonia in the ammonia soda process, and also for the recovery of sulphur from tank waste in the Leblanc soda process. In the compound steam engine there is an arrangement for admitting high-pressure steam into the low-pressure cylinder when starting the engine. The steam cylinders are 24in. and 36in. diameter, for high pressure and low pressure respectively, with a stroke of 36in. The steam valve gear is similar to that of the last. The air cylinders are double-acting, and of the single ram type, water being introduced into each cylinder, and this rises and falls up to the valve-boxes as shown with each in or out-stroke of the engine. There are four suction boxes in all, each of which, on the suction side, is fitted with ten valves 6in. diameter, and nine on the delivery side, each 6in. diameter.

When working, the CO_2 is drawn from lime kilns, and enters at the top of the valve-boxes, passes into the cylinder, and is there displaced through the delivery. Thence it passes through the receivers or carbonators, and these are kept under pressure until either H_2S (sulphuretted hydrogen) or ammonia gas is liberated, for whichever process they are required.

Though designed primarily for the compressing and delivering of CO_2, this compressor may equally well be used for dealing with air. The glands for the stuffing-boxes are surrounded by a water box, which keeps them luted and water-tight.

The enlarged section on Fig. 53 will give an idea as to the arrangement of the valves.

In the air compressors made by Hughes and Lancaster, of Ruabon and London, the air valves, both for suction and delivery, are cylindrical in form, and have a to-and-fro swinging motion imparted to them by means of an ordinary excentric, in a manner similar to that adopted in the well-known Corliss steam valves. In this way the valve is given a positive mechanical movement, which can be accurately timed to correspond with the positions of the air piston. Unlike the ordinary Corliss valve, this valve is made in the form of a hollow cylinder, which is divided diagonally by a midfeather, and in this way separated into two compartments.

These valves are fitted in seatings in the cylinder heads, as shown in Fig. 50, there being one valve at each end of the cylinder, each valve serving the double purpose of

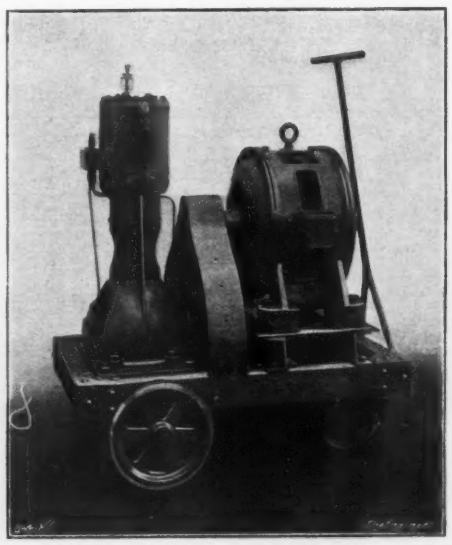


Fig. 58.—PORTABLE COMPRESSOR—LACY-HULBERT AND CO.

suction and delivery valve. It will be seen from the longitudinal section of the valve in the left-hand view in Fig. 50 that the compartments of the valve are open at the ends, one end opening into the suction chamber, and the other into the delivery space—that is to say, when the valve is placed in its casing, in which it is an easy fit, the opening at one end communicates with the passage A, through which the free air is supplied, and the other open end communicates with the compressed air chamber and passages F. In addition, this last opening into the delivery space is further provided with a lift valve H, which opens only when the air which is being compressed in the cylinder has at least attained the same pressure as that of the air in the receiver.

There are two ports cut through the side of the valve in the form of longitudinal slots. One of these—C, which may be called the free air port—opens into the compartment which is in free communication with the suction chamber A; and the other port E, called the compressed air port, opens through the valve H into the compartment which communicates with the passages for the compressed air. A similar slot, opening into the cylinder of the air compressor, is cut through the casing in which the valve works.

The motion imparted to the valve is such that the free air port commences to open to the air cylinder simultaneously with the commencement of the intake stroke of the piston, with a slight allowance for the re-expansion of the small quantity of air contained in the clearance space. In the figure, the piston is about to begin its movement to the right, and the suction valve is shown just about to open. This port again closes just as the piston reaches the end of its suction stroke.

As the piston commences its return or compressing stroke the compressed air port E begins to open and shuts exactly as the piston gets to the end of its compressing stroke. This commencement of the opening of the delivery port is shown in Fig. 50 as taking place at the right hand end of the cylinder.

As the motion is given to the valve by mechanical means, the opening and shutting of the ports at the right moments is assured, no matter at what speed the compressor is running, with the result that a high volumetric efficiency is attained. Careful tests have shown the volumetric efficiency of this compressor to be as high as 97 per cent.

By driving the valve at its free air end the necessity for providing a gland for the spindle to pass through is avoided. It will be seen that the valve ports are not very far apart on one side of the valve which is nearest the opening into the cylinder. In order to keep these faces close up to one another, compressed air is admitted so as to press upon the back of the valve. The pressure thus exerted holds the valve well up to the inner surface of the valve casing, and so prevents leakage. The motion spindle and the valve itself are made separately, and the movement communicated through an "Oldham" coupling K, so that the true rotary motion may be

Fig. 59—SMALL COMPRESSOR—LACY-HULBERT

given to the valve, although the two axes may not coincide when the face has become worn and the spindle has moved bodily nearer the face in following up the wear.

The lift valve H at the compressed air end of the cylindrical valve is provided with a dash-pot arrangement I, by which all hammering is avoided and the valve is enabled to run silently at high speeds. The compressed air naturally puts an end pressure on the valve, causing it to work tight against an inside shoulder at the free air end, but the greater part of this pressure is taken off by a balancing cylinder, which exerts an opposite pressure on the valve and causes it to work almost in equilibrium, the excess of pressure allowed on the end of the valve being only sufficient to prevent leakage taking place at this point. Friction is in this way reduced to a minimum, and easy and smooth running of the valve is attained.

One very important feature of this valve is the ease with which it can be taken out, examined, and replaced with very slight interruption to the running of the compressor.

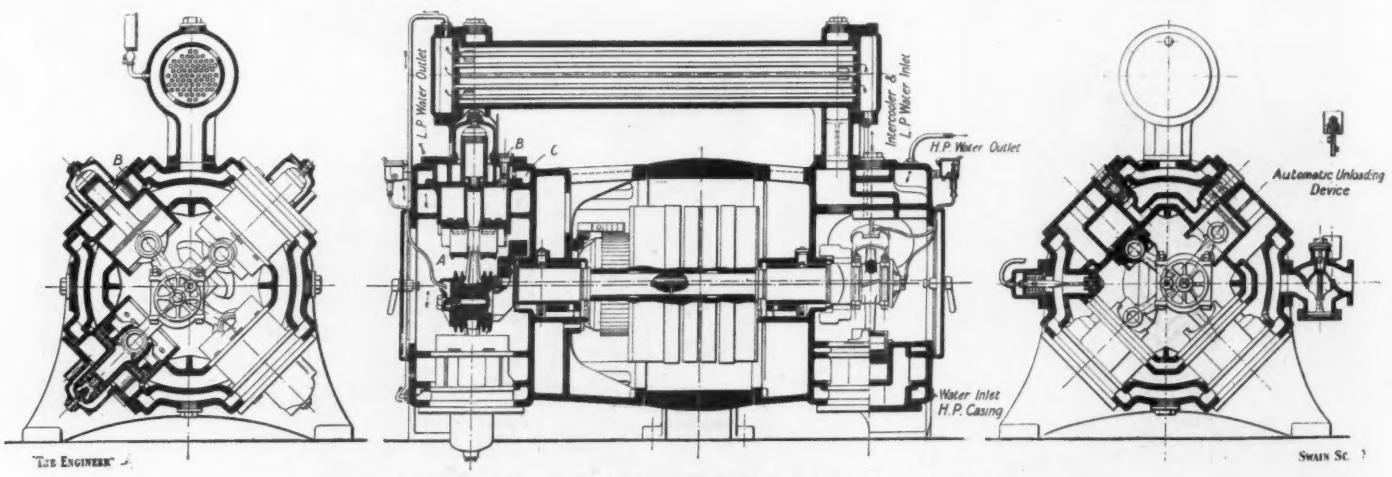


Fig. 60.—STANDARD TWO-STAGE COMPRESSOR—REAVELL AND CO., LTD.

The cylinders and cylinder heads are water-jacketed, the water spaces being marked W in Fig. 50.

As an example of a typical installation of compressed-air machinery of this design made by Hughes and Lancaster we give in Fig. 51 a side elevation, a plan which is partly in section, and a cross section of one compressor of a set of four, made for the Bombay Municipality. In this installation there are three Babcock and Willcox boilers, each having 426ft. of heating surface. The pressure of the steam is 170 lb. per square inch. These boilers are supplemented by a Green's economiser consisting of 168 tubes.

There are four sets of steam-driven air compressors, the steam cylinders being of the triple-expansion type, and each set of engines having its own jet condenser, the pumps of which are worked by an overhung crank on the end of the main crank shaft.

Each set has three double-acting air cylinders placed tandem fashion behind the steam cylinders, the piston-

rods being prolonged to carry the air-compressing pistons. The common stroke is 24in. In two of the sets of air compressors the steam cylinders are as follows :—High-pressure 12in. diameter, intermediate 19½in., low-pressure 31½in. The six air cylinders belonging to these two sets are each of 22½in. diameter.

The other two sets of compressors are smaller than the above, the steam cylinders being :—High-pressure 8½in., intermediate 14in., and low-pressure 22½in.

Fig. 54 shows a small vertical compressor made by the same firm, which is arranged for driving by an

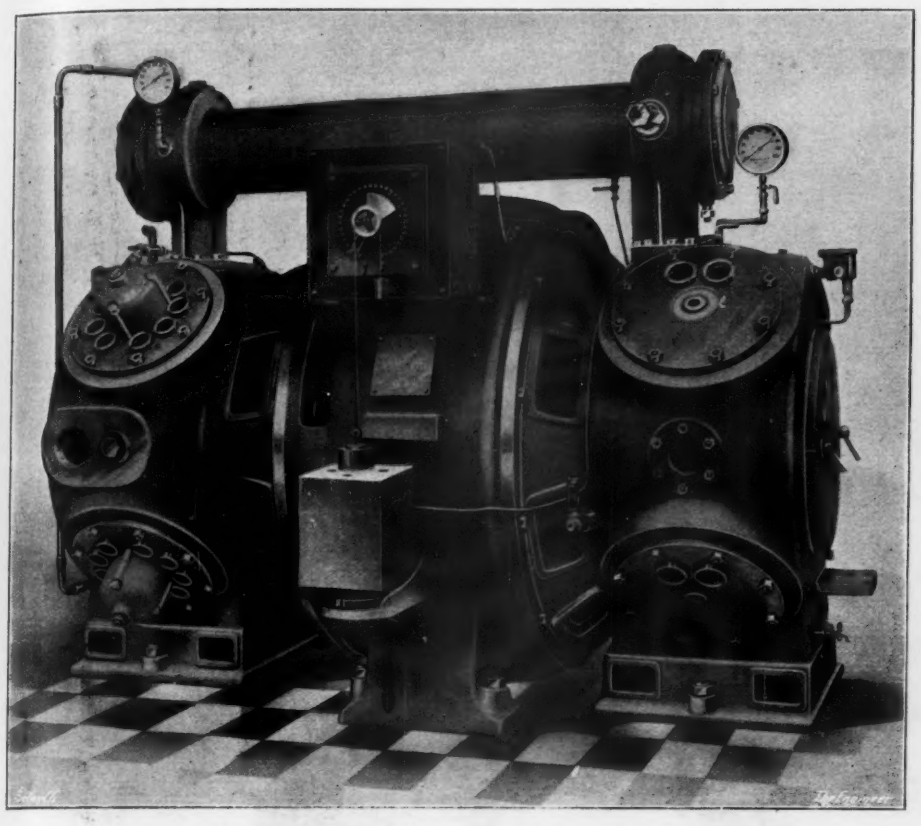


Fig. 61.—TWO-STAGE ELECTRICALLY-DRIVEN COMPRESSOR—REAVELL AND CO., LTD.

electrical motor. This gives a very compact arrangement, and is suitable for use in cases where the quantity of air required is not large, and where a high pressure is not wanted, but where only a very small space can be spared for the compressor.

In Fig. 55 is a reproduction from a photograph of a horizontal single-acting compressor driven direct by an oil engine. The small pump at the side provides the necessary circulation of water through the jackets.

These compressors of Hughes and Lanchester are chiefly made for use in connection with the Shone

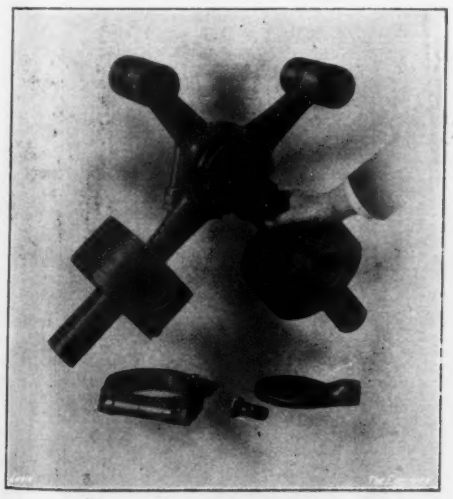


Fig. 62.—PISTONS AND RODS OF REAVELL COMPRESSOR

system for lifting sewage. The firm manufactures all the necessary appliances in connection with this system, such as the ejectors or vessels into which the sewage is allowed to flow by gravity, and from which it is afterwards forced by the pressure of air admitted by means of a float, which rises as the vessel fills.

As far as can be judged from a careful inspection of the compressor constructed by this firm, it appears to possess all the merits claimed for it by the makers. When running all the mechanism works very sweetly, and what is especially noticeable is that the valves are quite noiseless in their action. Another striking quality of this machine is the readiness with which the valves are removed. To do this nothing more is required than to take off a cover, which is very easily done, and to lift out the valve with its spring and dashpot. As everything is simply fitted into its place in the valve chamber, and there are no attachments, everything can be lifted straight out when the cover is taken off and can be just as readily replaced.

The firm of Lacy-Hulbert and Co., Limited, devotes itself chiefly to producing small compressors with capacities up to 300 cubic feet of free air per minute, and for pressures up to 180 lb. per square inch. Many of these are made portable, and are driven by petrol engines, electric motors, or gas engines. The valves used in these machines are, both for suction and delivery, of the simple disc pattern. Those for suction have no springs, while the delivery valves are provided with simple coil springs. An inspection of the following illustrations will serve to indicate not only the number of uses to which the compressors made by this firm are put, but will show what a wide field has been and is continually being opened for the employment of compressed air. The view shown on Fig. 56 is taken from a photograph of a portable compressor driven by a petrol engine and built for use in desiccating telephone cables. Fig. 57 shows a two-speed compressor driven by a gas engine. It is fitted with an air receiver and water tanks. This machine is used for supplying air to be employed in caulking large gas mains, and also for testing the joints when made. By having the two-speed gear the compressor can be arranged

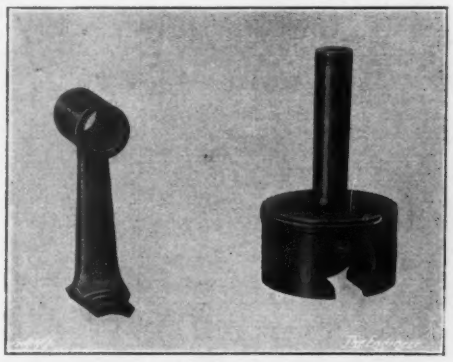


Fig. 63.—PISTON AND CONNECTING ROD—REAVELL

either to supply a large quantity of air at a low pressure or a small volume at a high pressure, according to the requirements of the user.

Fig. 58 shows a portable compressor which is driven by a single-phase electric motor, and is used in electric power stations and factories. Fig. 59 is a view of the smallest compressor made by this firm, having a capacity of only 5 cubic feet of free air per minute. It works up to a pressure of 150 lb. per square inch.

The essential feature of the compressors made by Reavell and Co., Limited, Ipswich, is the arrangement by which the compression is effected in four cylinders, which are set at angles of 90 deg. round the centre of the crank shaft. The pistons in all the cylinders are single-acting, and are arranged as trunk pistons, so as to be linked direct to the crank. All these rods go to one crank, so that there is one-quarter of a revolution difference in cycle between each adjacent cylinder. Moreover, the rods are always in compression, and

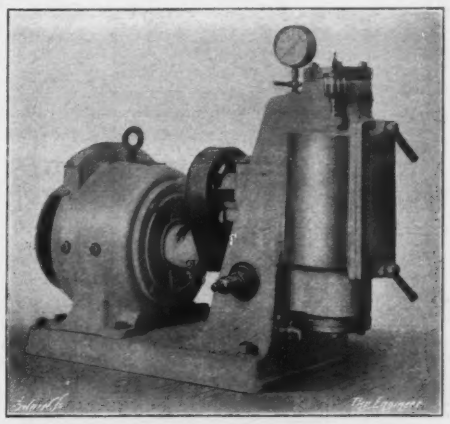


Fig. 64.—DUPLEX COMPRESSOR—REAVELL AND CO

the connecting rod ends only bear on the crank pin for rather less than one-quarter of the circumference.

A typical compressor which is now being made by this firm is shown in section by Fig. 60, and a general external view of the same machine is shown by Fig. 61. In this machine the low-pressure cylinders are the four at the left-hand end of the compressor. These are shown in transverse section in Fig. 60. The free air is allowed to pass into the central space A in which the crank turns.

Fig. 65—Two-Stage Westinghouse Compressor

At the point where the end of the connecting-rod bears against the piston there is a port communicating with the space inside the compressing cylinder, and there is a corresponding port in the connecting-rod end. The positions of these is so arranged that when the piston is just beginning its return stroke, after the delivery of the air, the port in the rod end is just beginning to open to that in the piston. The result is that the free air passes through the ports into the inside of the cylinder, and this goes on until the end of the suction stroke is reached, when the ports are again closed. On the return stroke this air is raised in pressure and discharged through the spring delivery valve at the top of the cylinder. The delivery valve is marked B in the drawing. Thence the air passes into the passage C, and through the inter-cooler to the inner crank chamber of the high-pressure cylinders, where, after being compressed, the air is dis-

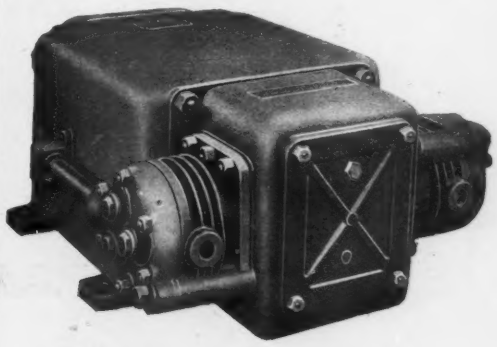


Fig. 66—ELECTRIC COMPRESSOR—WESTINGHOUSE

charged into the receiver. The compressor here illustrated is driven direct by a motor placed between the high and low-pressure ends. It will be seen that each of the compressors is divided into three annular spaces by circumferential walls. The middle space forms the water jacket for cooling, the outer one is for the air delivered from the cylinders, and the inner space is for the free air in the low-pressure compressor, and in the high-pressure end is filled with the half compressed air from the low-pressure end after it has left the intercooler.

The machine represents Reavell and Co.'s standard two-stage machine, as used for supplying air for pneumatic tools in dockyards, arsenals, and private engineering and shipbuilding works in this country and abroad.

COMPOUND TWO-STAGE STEAM OR ELECTRIC AIR COMPRESSOR

WALKER BROTHERS, LIMITED, WIGAN, ENGINEERS

(For description see page xix.)

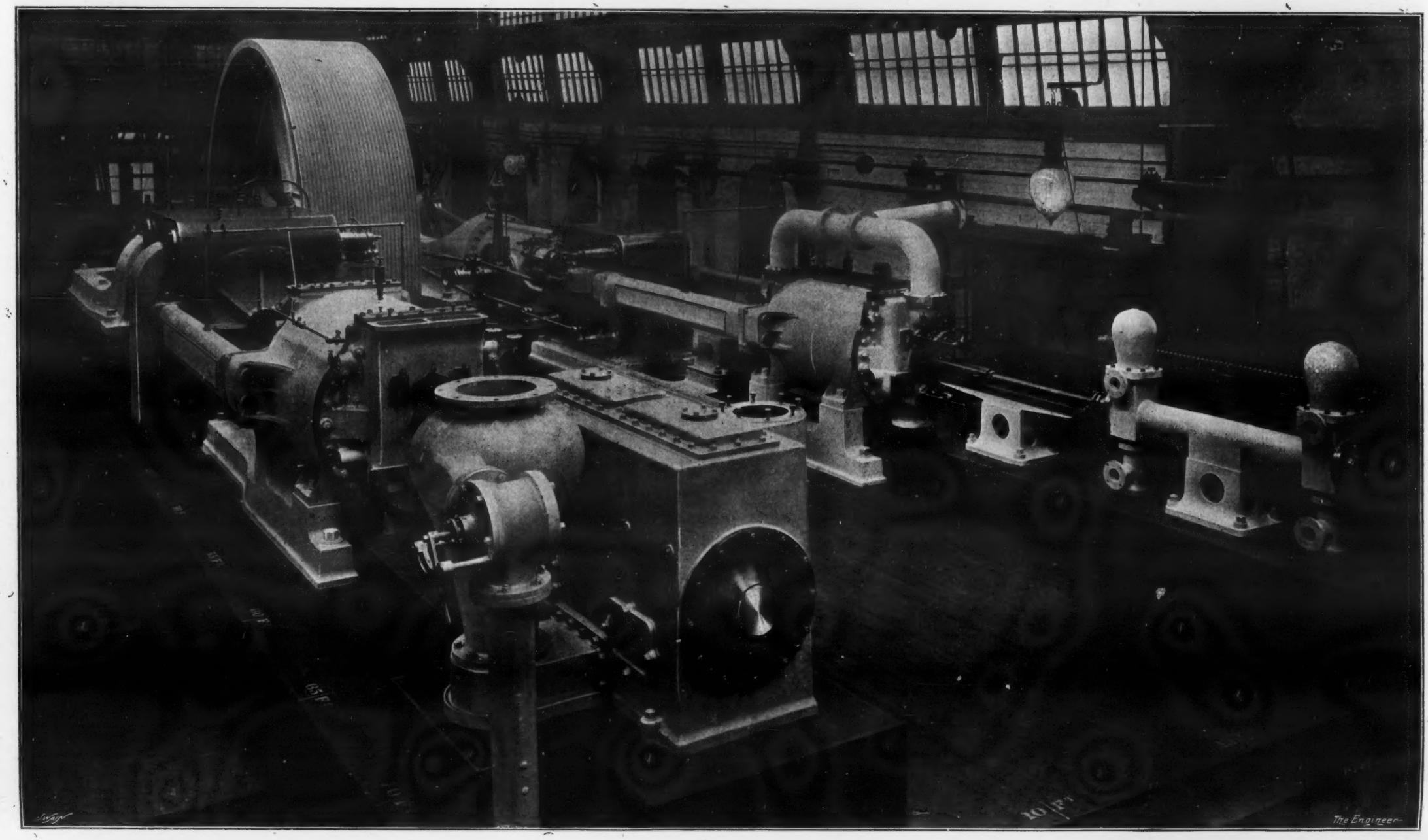


Fig. 62 shows a view of the four pistons and rods of one of these compressors. A piston and rod is seen in Fig. 63. It may be pointed out that the compressors, both single stage and two stage, are arranged for driving with steam, belt, or with gas or oil engines. Fig. 64 is a view of a duplex compressor in which there are two instead of four cylinders on the one crank.

Besides compressors of the ordinary automatic valve kind, having spring-controlled suction and delivery valves fixed in the cylinder ends, as well as compressors in which both suction and delivery valves are mechanically controlled as in the Corliss gear, the Worthington Pump Company make a compressor dependent for its air

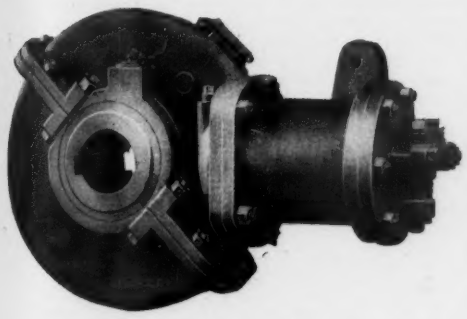


Fig. 67—COMPRESSOR FOR ELECTRIC TRAINS

movements upon what the company calls its "Cincinnati" valve gear. This valve gear is designed positively to control the three constant points in the compression cycle, namely, the opening of the suction, the closing of the suction, and the closing of the delivery. The opening of the delivery, which is the variable event in the cycle, is effected by means of lift valves held by light springs. On the air in the cylinder attaining a pressure which is equal to that in the receiver, or slightly above it, it lifts these poppet valves and passes through. At the end of the stroke the delivery is mechanically cut off by means of a semi-

Fig. 68—MOTOR DRIVEN COMPRESSOR

rotary Corliss valve, thus retaining under the delivery valves a cushion of air at receiver pressure. These lift valves are therefore given the entire return stroke in which to seat themselves, and all tendency to violent and noisy impact is avoided; while the mechanical cutting off of the delivery, in relieving the lift valves of the necessity for sharp closing, allows the use of the light springs, and it also ensures a full wide opening at the beginning of the delivery, a feature which is lacking in a delivery valve under complete mechanical control.

We understand that this company has built a number of Cincinnati compressors of very large capacity.

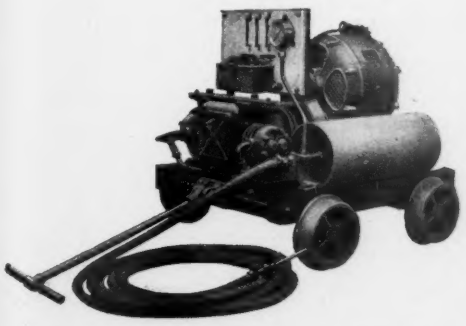


Fig. 69—PORTABLE ELECTRIC COMPRESSOR

The compressors made by the Westinghouse Company for use with the air brake are well known to all our readers. They are also used for other purposes where their small size and the convenience with which they can be attached to a wall or pillar give them an advantage. In addition to the standard sizes, these compressors are made with various sizes of air and steam cylinders to meet special conditions of service.

Fig. 65 illustrates a modification of the general type, and is a two-stage compressor suitable for steam pressures above 150 lb. per square inch. Fig. 66 is an outside view of a motor-driven compressor of a type used, amongst other things, for electric cars and trains. The motor can be turned round 180 deg. on the compressor, so that the apparatus may be either bolted under a car direct to the frame, or on the floor, as may be desired. All wearing parts are continually oiled automatically while the motor is running, and just sufficient oil is fed to the pump cylinder to ensure proper lubrication. Fig. 67 shows another compressor for trains and cars. It is driven by an excentric on the axle. The excentric is made with an extended sleeve, which forms the bearings for supporting the compressor casing. The bearings are steel bushed, white metal lined, so as to be quickly and easily replaced and renewed when worn. The single-acting air-cylinder is mounted on the casing, which is supported from the car frame by a flexible attachment. This compressor is particularly adapted to cars the speeds of the driven axles of which do not exceed 150 revolutions per minute, corresponding to about 13½ miles per hour for 30in. wheels. Fig. 68 illustrates a motor compressor for stationary work, and Fig. 69 is a portable motor-driven air compressor. These are made in different sizes, for either direct driving by a direct current motor, or through gearing by an alternating current polyphase motor as shown in the illustration.

An interesting air-compressing plant of large size, made by Walker Bros., of Wigan, forms the subject of the illustration on page xviii. At the time they were erected, some two or three years ago, they were the largest engines of their kind in India. They supply air to the mines of the Champion Reef Gold Mining Company, and, whilst driven normally by electricity, they can, at very short notice, be converted to steam driving. The electric power is derived from the Cauvery Falls.

The steam and air cylinders are, it will be seen, placed in tandem, and the fly-wheel is grooved to take ropes, by means of which it may be driven by a motor. The steam cylinders are 32in. and 57in. diameter, and the air cylinders 32in. and 51in. diameter, all with a 5ft. stroke. The steam is distributed by Corliss valves, and is condensed in a jet condenser at the rear of the engine. We are informed that a cylindrical form of condenser, instead of rectangular, is frequently employed by Walker Brothers. The air is cooled in its passage between the first and second stage. The engines are designed for a steam pressure of 110 lb., and deliver air at 80 lb. The fly-wheel is 24ft. in diameter and weighs about 34 tons; in its periphery are twenty-eight grooves for cotton ropes.

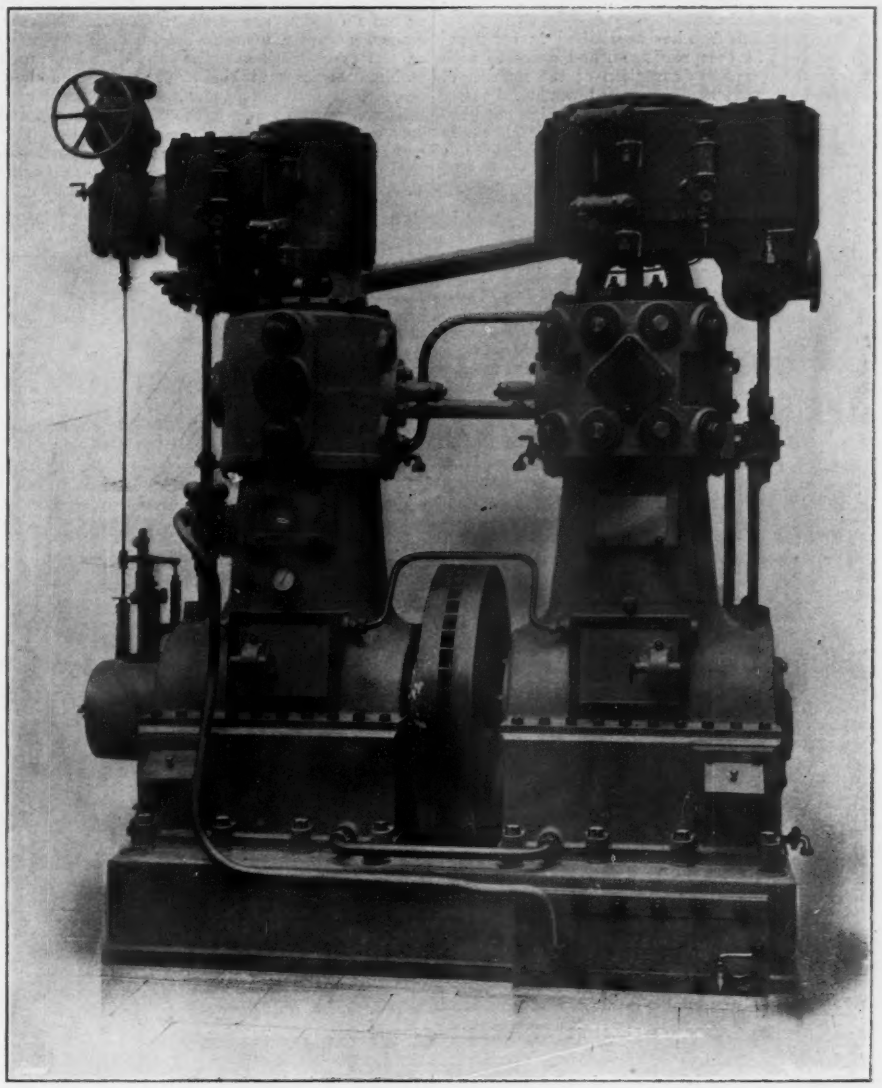


Fig. 70—VERTICAL STEAM DRIVEN COMPRESSOR—BROTHERHOOD

The air valves are placed in the cylinder covers, so as to reduce the clearance to a minimum, and when closed they so fill the port openings as to present a perfectly flat surface inside the cylinder and permit of the piston coming almost up to the end. About one-third of the area of the cover is occupied by the admission and the same amount by the outlet valves. The valves are suspended from the top in the manner of a hinge, and close by gravity, and there is only one of each kind at each end of the cylinder. They are partly balanced by moderate elastic pressure, and an externally-applied india-rubber buffering apparatus ensures their closing with but little noise even at high speeds. Arrangements are made

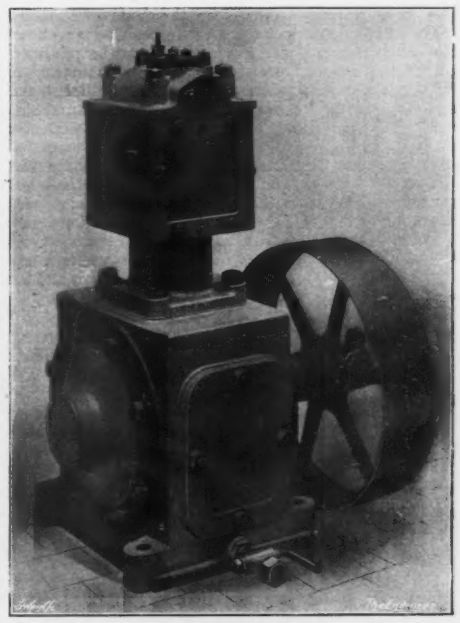


Fig. 71—BELT DRIVEN COMPRESSOR

so that the valves can be got at without disturbing the cylinder covers or other parts of the engine. The pump driven by the tail rod of the high-pressure engine circulates the cooling water through the jackets and intercooler.

The "Brotherhood" type of compressor is probably best known in connection with marine work, for which it is made for both high and moderate pressures in the works at Westminster, and is used in nearly all the navies of the world, as well as in dockyards and shipbuilding establishments.

For many years this firm has specialised in construction of machinery for compressing air and gases to high pressures, and a complete description of the number of types which have been made and used would fill many pages. Of these, one machine of recent design has been selected for brief notice here. The example shown in Fig. 73 is a machine for compressing air to high pressures for charging torpedoes, operating torpedo discharge tubes, compressing gases, and similar purposes. The leading characteristics of this machine are its simplicity, compactness, and lightness. Accessibility of parts has also been carefully considered. The particular machine illustrated is steam-driven, the steam cylinders being shown on either side of the pumps. This compressor, however, is not infrequently driven by an electric motor. The air is compressed in four stages, and thoroughly cooled between each stage in intercoolers. The valve gear is simple and accessible, separate delivery and inlet valves being provided for each stage, any or all of which can be removed from the upper side of the pumps. A double-acting water pump for cooling purposes is fitted on the base of the compressor and driven direct from the crosshead as shown. This pump circulates water round the pump barrels, intercooler coils, and valve chambers. The steam and air piston-rods are in duplicate to ensure parallel travel. The steam valves are of piston type. These machines are supplied for any working pressure up to 3500 lb. to the square inch.

Low-pressure machines suitable for pressures from 5 lb. to 500 lb. per square inch are designed and built on lines distinct from those adopted for the high pressures already described, and from the illustrations, Figs. 70 and 72, their likeness to enclosed steam engines will be observed. The design is a vertical one, to reduce the wear and friction to a minimum, and also with a view to saving floor space. It is not possible in this article to describe in any close detail the many types and sizes. In general, it may be noted that all these compressors are of enclosed type, fitted with forced lubrication. They can be driven by steam, gas, and oil engines, electric motor, and belt, and the smaller sizes are also supplied coupled to petrol engines.

The illustrations given show three examples of these methods. As will be seen, they are built with one, two, or more cranks, according to requirements, and, of course, compression is effected in single or plural stages, as the case demands. The air cylinders are double acting, compression taking place at each end alternately, the air, in compound machines, then passing through intercoolers on its way to the higher pressure cylinders. The cylinder barrels and covers as well as the valve passages are water-jacketed, the water circulating through the cylinder jackets and covers and also through spaces surrounding the valve passages. Where the ultimate pressure required calls for two or more stages of compression, it is preferable to use two or three-crank machines, but, if for reasons of space or otherwise this cannot be done, the single-crank type are fitted with trunk pistons, each stage of the compression taking place on top and bottom of the piston respectively.

It should be added that special attention has been bestowed upon the air valves, and the valves and springs are removable independently. The inlet and discharge valves are similar in design, but with their seatings reversed for changed direction in flow of air. No joint packing is needed throughout the compressors, as all joints are well ground. The valves are easy of access and are very light.

Another point to be noted is the governing. In steam-driven plants a combined steam and pressure apparatus is fitted to keep a constant pressure in the air reservoir, while the discharge may be fluctuating through the full range of the machine's output. In electrically-driven compressors regulators are fitted to vary the output of air as desired, while the speed of machine remains constant. This method permits of a motor of minimum capacity being used, and tends to simplification of electrical regulating gear. This method of governing is also adopted for belt-driven plants, and automatic belt shifting gear is also provided when required.

The large two-crank machine shown by Fig. 70 is driven in this instance by steam, and represents a size capable of delivering about 500 cubic feet of free air per minute compressed to 100-120 lb. per square inch. This is a size in which many have been supplied to the Royal Dockyards.

Fig. 72 illustrates a single crank compressor fitted for electric driving with a "motor" cylinder added above the pump. The particular machine shown was specially designed for tunnelling work, and the principles followed will probably be of interest to engineers engaged in similar work. The machine was primarily intended to supply compressed air to the workings. It was, of course desirable that the air should be as cool as possible, and when it was returned at nearly the full pressure, though vitiated, considerable available energy remained. In order to save this energy, and at the same time to economise in cost of water for cooling the compressed air, an expansion cylinder was fitted to the compressor. Air from the workings was taken back to this expansion cylinder, and assisted in driving the compressor. After expansion the air was greatly reduced in temperature, and was exhausted through the tubes of a cooler resembling a surface condenser. The cooling water, after becoming heated in the compressor jackets, was passed through the space surrounding the tubes in the cooler, and was thus brought back to a sufficiently low temperature to be again used. A similar cooler was fitted in the air delivery main for the compressor, and the cold water was first passed through this to give a low temperature to the air supplied to the tunnels. By this arrangement a large saving in electric power and also in cooling water was effected. It may be added that plant of this kind was built for use in the construction of the London railway tubes.

The small machine shown—Fig. 71—was developed for dealing with cases where small outputs of, say, 10-100 cubic feet free air per minute are required. This is built on similar lines to the larger machines, but is fitted with splash lubrication. It is shown ready for belt driving, but is built for motor and other drives, and also on a portable wheel fitted base when required. These small machines are very useful for cleaning purposes, working mining drills, a few pneumatic tools, charging air brake reservoirs, and so forth.

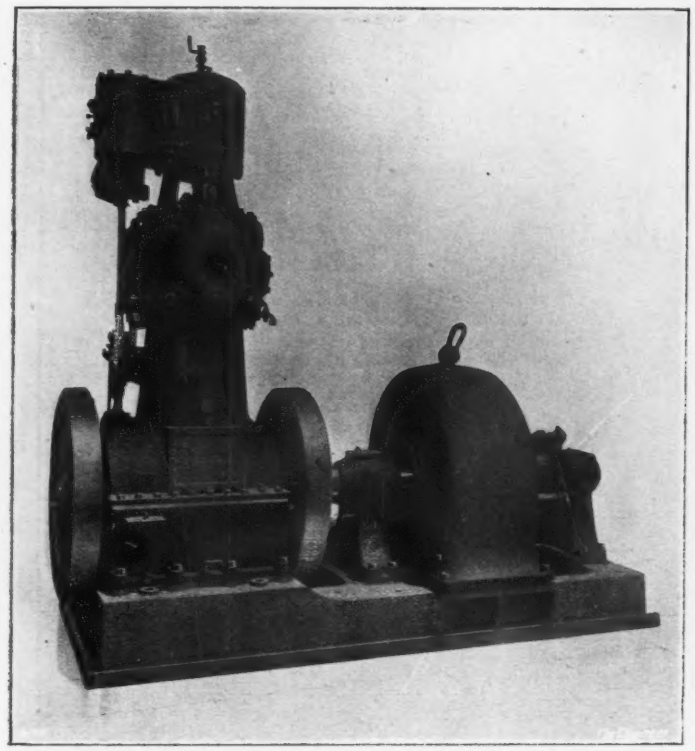


Fig. 72—STEAM OR ELECTRIC COMPRESSOR—BROTHERHOOD

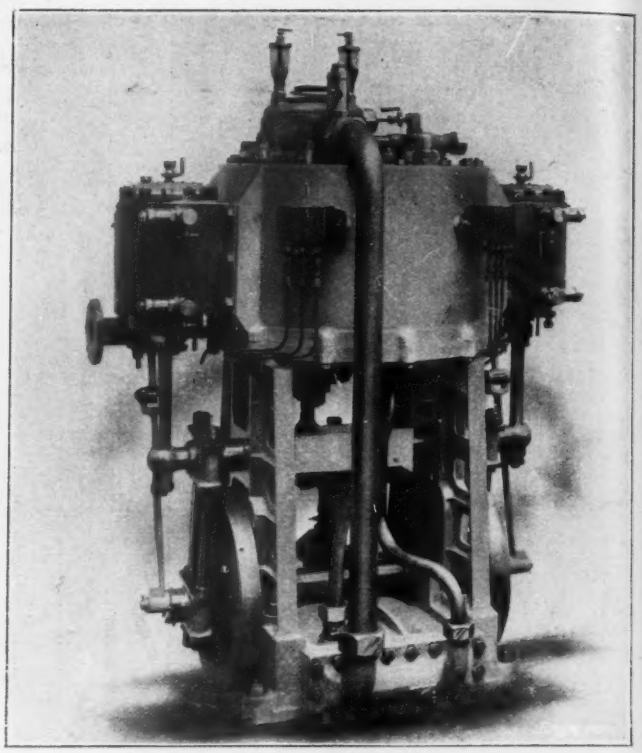


Fig. 73—HIGH-PRESSURE COMPRESSOR—BROTHERHOOD

THE COMMERCIAL ORGANISATION OF ENGINEERING FACTORIES.

By HENRY SPENCER.

No. IX.*—COSTS DEPARTMENT *(continued)*.

Apprentices' wages.— In regard to apprentices and improvers, whose wages are subject to periodical advances with their advancing years, it is very desirable to adopt some means whereby the dates on which such advances fall due shall come under review, and the accruing advances be brought under the notice of their respective foremen for verification. There can be no diversity of opinion as to the importance of carrying out with promptitude any existing rule in this connection, and unless there is good reason for withholding an advance as punishment for breaches of regulations, &c., an apprentice will reasonably expect his increased pay at the recognised intervals. The "Apprentices' and Improvers' Advances" book and monthly chart, shown by Figs. 59 and 60 respectively, may be relied upon for the necessary records, bringing the name of each apprentice under review with regularity, involving far less labour in the wages department than would result from an absence of system, and assisting very materially to promote that tone among the apprentices which a just and due recognition of their rights alone can produce. The book referred to is arranged for the classification of their names in alphabetical order, and the monthly charts are carried in a pocket at the back of the book. At each succeeding week the chart is consulted for any advances that have become due; with the sanction of the foreman the new rate, &c., is entered in the Advances Book simultaneously with the Wages Book, and old charts superseded and destroyed immediately they have served their purpose, so that at no time are more than thirteen charts carried in the pocket.

FIG. 59.—*Apprentices' and Improvers' Advances Book. Right Side.*

Name.	Shop No.	Dept.	Date of Birth.	Commenced. Date.	Rate.
Baxter, S.	503	S			
Bedwell, R.	360	L			
Berry, A. L.	141	B			
Binner, C. E.	426	P			
Blackburn, J.	239	D			
Boardley, F.	271	F			
Brown, J.	199	C			
Brown, R. T.	330	K			
Burton, J.	472	S			

FIG. 59.—*Apprentices' and Improvers' Advances Book. Left Side.*

WAGES ADVANCED.

Date.	Rate.	Date.	Rate.	Date.	Rate.	Date.	Rate.

B

C

D

E

FIG. 60.—*Apprentices' and Improvers' Advances Chart.*

SEPTEMBER, 1906.

Name	6	13	20	27
O. Williams	✓			
J. Brown	✓			
H. Hanson	—			
J. Nichol		✓		

Orders to factory.—The routine necessary for compiling the cost records of jobs proceeding through the shops must very largely depend upon the system that is in vogue in the manufacturing department, not only as to the quantity of parts stocked and the system of putting the work in hand, but also in the method adopted in the assembling and fitting, and final erection. For it must be clearly understood that the costing system must be moulded and adapted to the factory; not the system of manufacture modified to suit the commercial department. This is a proposition that is associated with the elementary principles of factory accounting practice; but though it is quite obvious that to suggest the *raison d'être* of the shops shall be subservient to the statistician is altogether illogical and impossible, its recognition is by no means common or universal. It is in this connection that there must be unity and concurrence between the productive skill of the engineer and the mathematical ability of the organising accountant, and the result of the combination must be apparent in a perfect mutual understanding onward from the moment of issuing the order for manufactured supplies. Following the issue of drawings to the shops, and before any steps can be taken towards recording costs of production, it must be ascertained by what rule departmental operations are to be controlled. Doubtless until finality is reached in the "designing-office," there must be some limit recognised in the manufacture of the many component details of the car, or it would inevitably result that some parts would be overstocked, and others not at call when required. The desire for economical production, that underlies the introduction of a wages bonus system, is also a determining factor in the decision as to what quantities of each part shall be placed on requisition, and in this matter the producing capacity of the factory is considered in relation to matters of finance and outside demand. For the purpose of justifying the system to be described, it may be assumed that, from a perusal of the office orders issued to factory, it is desired to put in hand twenty cars of a specified type, and that the necessary drawings for same have passed into the hands of the various foremen, simultaneously with the Shop Lists, a complete copy of which will be required respectively by the works manager, costs, stores, and contracting departments also. Under the direction of the costs department, whose duty it is to allocate job card numbers in the manner to be described, these lists are drafted from the drawing-office copy, and bound together in cheap files of the "Stolzenberg" type, by a typist, and handed to the officials concerned. Incidentally it may be mentioned that each foreman will mark with a "tick" each batch of details as he gives them out to his men, and indicate delivery to "Finished Stores" by a "cross tick," so as to show the progress of the work.

The custody of shop drawings.—In view of the fact that the work involved is largely repetitive, particularly if the types of cars manufactured are few, it will be obvious that the shop drawings will be in repeated requisition so long as the particular type referred to remains standard practice. There must, therefore, be suitable provision made for locating each drawing, as it cannot be permitted that there shall be loss of time, with machines standing idle, while a prolonged search is made for the required drawing, neither should it be overlooked that a loose system of control opens the door for pilfering what is private and valuable information. The need is efficiently met by providing light wooden racks, in which drawings of general arrangements are filed vertically, within ready access of fitters and erectors, while the smaller drawings of details may be contained in drawers, conveniently placed, preferably in the vicinity of the marking-off table or gauging room, and arranged vertically in alphabetical order, the forge, pattern shop, &c., having their own separate arrangements.

The racks and drawers are under control, and the issue of the drawings is only permitted on the presentation of a printed slip, dated and bearing the name of the workman for whom the drawing is required, the same being filed away, as a receipt, until the drawing is returned and exchanged for the same. The calls for drawings are thus met expeditiously, without burdening the manufacturing department unduly, and responsibility for missing drawings is placed beyond the range of doubt and uncertainty.

Factory orders.—All instructions to the factory for work to be put in progress are given in writing, whether the jobs be car repairs embodied in an office order, details of cars, as per shop lists, or relating to the factory plant and fabric. The triplicate copies of the office order are handed by the works manager to his clerk, who retains one copy for reference, and delivers the remaining copies to costs and forwarding departments respectively, where they are filed for future reference. Simultaneously with the receipt of this, the costs department prepares the necessary instructions to the foremen of the departments concerned, as shown in the form of factory order, Fig. 61. The necessary particulars are dictated to a typist, who prepares the required number of copies, which are pasted in the departmental order books, being checked and issued by the costs accountant.

FIG. 61.—*Factory Order. Size, 7in. by 5in.*

FACTORY ORDER.

No work must be done without instructions on this form.

Factory order. No.....	To department.	Date of order.

To be completed.....

Signed.....

Drawing No......

Remarks.

The departmental order books, in which these are affixed in numerical order and folded so as to leave the number unobscured, are plain guard books provided with an A-Z index, so that the various factory order numbers relative to each customer or establishment account can readily be found. Orders for saleable stock are distinguished from those having reference to establishment extensions and maintenance by printing in distinctive colours. The office orders relating to the same are marked with the number of the factory order, and *vice versâ*, for the purpose of identification. Stated briefly, the function of the factory order is the authorisation for work to commence on (*a*) batches of car details in accordance with the shop lists already referred to for delivery to finished stores' room; (*b*) repairs and replacements required by customers; (*c*) the manufacture and repair of patterns, jigs, and similar special requirements of the factory, with additions and repairs to existing buildings and plant in general. Mention of the order number is sufficient to enable the forwarding clerk to refer to his instructions on the office order as to the dispatch of goods, and in the work of costing the same number is allied to a card number—identical with the reference number given on the shop drawings—for the purpose of arriving at the manufacturing cost of each batch of parts as set forth on the shop lists, which are drawn up in sections, as road wheels, axles, springs, frames, steering gear, &c.

Costs of material.—With the issue of the factory orders and shop lists the necessary material is withdrawn from the rough and finished stores rooms respectively, and work commenced in the factory forthwith. The requisitions are made in writing, and subsequently recorded in the "Stores Issued" book—Figs. 62 and 63—by the stores clerk, and from thence in the stores' ledger, Fig. 23.

FIG. 62.—*Rough Stores Issued.*

Date.	Factory order.	Card. No.	Description.	Patt. No.	Weight. lb.	Value.	Stores ledger.

FIG. 63.—*Finished Stores Issued.*

Date.	Factory Order.	Card No.	Description.	Origin.	Value.	Stores ledger.

Both the rough and finished stores, issued records, illustrated above are loose sheets of foolscap size, having distinctive tints to assist the costs and stock audit clerks respectively in their work of posting, and are numbered in the top right-hand corner. They are contained in "Premier" files, so that any sheet may be removed when required without disturbing the remaining sheets, and possess a marked advantage over the bound book in that the work of writing up the issues and posting the same into both costs and stock records may proceed uninterrupted among the necessary clerks simultaneously. The "finished stores" room is the repository for all details actually manufactured in the factory—so named to distinguish them from parts bought in, whether in the rough or finished; and sections of the cars that are assembled and fitted up in readiness for final erection are also herein temporarily deposited. As far as possible these finished parts are "tagged" or otherwise marked, at the time they are received, with the factory order number to which their cost has been charged, and when reissued, this order number is entered in "origin" column for the guidance of the costs department.

Stores requisitions.—The form of requisition for material, shown in Fig. 64, meets all needs of the case. It is bound in pads of fifty duplicate pages, perforated on alternative forms, so as to allow a carbon copy of each requisition to remain with the foreman for reference, and it is on this form that the woodshop foreman, &c., will advise the head storekeeper as to material used which is not actually under his eye. In considering the issue of material, it must be remembered that bars for the sawing machines and automatic lathes, sheets for such details as bonnets and tanks, &c., will necessarily be overdrawn from time to time, for obvious reasons of convenience, and the surplus material subsequently returned to stores room. Fig. 66 is a "returns slip," to be handed into stores room with scrap or surplus material, and the storekeeper's record of the same is shown in Fig. 67.

FIG. 64.—*Requisition for Material. Size, 4in. by 4in.*

FOREMAN'S REQUISITION FROM STORES.

.....190...

Please supply

.....

.....

.....

.....

Pattern No......*Class*.....

Shop order.....*Card No.*.....

(*Signed*)

.....

Foreman.

The workmen's schedule of parts, of which Fig. 65 is a specimen draft, is the form of requisition used in the

FIG. 65.—*Schedule Requisition.*

Schedule No. 36.

SETS 12 H.P. OIL PUMP FOR ORDER.

Drawing No. 559/12.

Quantity.	Description.	No. per car.	Card ref. No.	Foreman's sanction.	Issued by.
	Pump body	1	476		
	Plunger	1	477		
	Crosshead	1	478		
	Packing gland	1	479		
	Gland nut	1	480		
	Locking piece for do.	1	481		
	Suction valve	1	482		
	Delivery valve... ...	1	483		
	Valve chamber cap	1	484		
	Union for suction ...	1	485		
	Union for delivery ..	1	486		

* No. IX. (*continued*) appeared June 8th.

fitting and erecting shops. The schedules are drafted so as to conform with shop practice in regard to the assembling and fitting up of sections of the car, and the final erection of those sections, reducing the clerical work involved to a minimum, and not only displays at a glance what parts have already been withdrawn, but entirely removes the possibility of careless workmen obtaining duplicate supplies to replace parts lost or spoiled. The schedules are prepared by a typist on the "Mimeograph" copier, and issued from the costs department with the factory order.

FIG. 66.—*Material Returned. Size, 4½in. by 4½in.*

MATERIAL RETURNED TO STORES.

To Storekeeper. *Date*.....190 ..

The following drawn from Stores for Factory Order No..... *Card No*.... ..... *has not been required, and is now returned.*

DESCRIPTION.

This form of advice as to overdrawn and (or) scrap material returned to stores-room is bound cheaply in pads, similarly to those described by Fig. 64, and the record of such returns on the form shown in Fig. 67 is prepared from the above slips by the storekeeper's clerk for the purpose of the stock audit and the costs. Fig. 67 is a foolscap sheet, and is carried in a "Premier" file for preservation and reference.

Fig. 67.—*Departmental Returns.*

DEPARTMENTAL RETURNS.

Month of.....19.....

Date.	Factory Order No.	Card No.	Description.	Weight, lbs.	Rate.	Value.	Stores ledger.

Wasters and spoiled work.—It has already been mentioned that faulty castings, careless or incompetent workmanship, and occasional vagaries of machine tools conduce to leakages and waste that, however unavoidable, should be discovered, exhibited, and inquired into promptly as they arise. Each factory order or schedule specifies what quantities will be required from store-room, and the record of material issued shows when the authorised quantities are exceeded. The nature of and reason for such extra withdrawals should be ascertained before duplicate supplies are obtainable, and the necessary prominence is given to each case by the use of the "waster record" shown by Fig. 69. This record is a foolscap book written up in the rough stores-room from the foreman's "waster slip"—Fig. 68—and is brought under the periodical notice of the works manager, who

FIG. 68.—*Wasters Slip, Tinted. Size, 4½in. by 4½in.*

WASTERS DELIVERED TO STORES.

To Head Storekeeper,

The following parts, machined to Order No....., *Card No*....., *are herewith returned as wasters, due to*.....

.....

DESCRIPTION—

.....

.....

Signed.....

FIG. 69.—*Waster Record.*

WASTERS RECEIVED FROM FACTORY.

Month of.....19.....

Date.	Ex Factory Order No.	Card No.	Description.	Remarks.	Chgd. to.

instructs as to the ultimate disposal of the wasters. The manufacturing cost of replacing the same is charged against the department concerned as an establishment charge in accordance with a later reference to "standing order numbers."

SANTA CRUZ and the north and east of Chuquisaca turn out annually some 750,000 lb. of raw, unrefined cane sugar, which is consumed for domestic purposes. The method of manufacturing it is most primitive, the cane being crushed by horizontal stone rollers driven round by an ox harnessed to a pole. The surplus of cane is fermented into alcohol of indifferent quality.

COAST EROSION AND RECLAMATION.

No. VI.*

THE WEST COAST.

Land's End to river Severn—Figs. 17 (*ante*) and 18.—The physical characteristics of the north coast of Cornwall and Devon are very similar to those we have just described in the case of the southern littoral. Igneous and metamorphic rocks form the bold and precipitous cliffs, extending from Land's End to St. Ives. Thence northward to Tintagel Head, the geological formation is Devonian. North of Tintagel carboniferous strata, represented by limestones, grits, culm measures, and other rocks form the coast line as far as Barnstaple Bay. Extensive deposits of blown sand are met with in many of the bays and indentations. The drifting of these sands has frequently resulted in lands and buildings being buried beneath them.

The cliffs in Barnstaple Bay consist of carboniferous grits and sandstones, the gradual erosion of which has supplied material for the formation of the beaches and ridges of large boulders which skirt the bay between Hartland and Barnstaple. The boulders and pebbles are carried round the bay from west to east, in the direction of the flood tide, and in places form huge deposits, raised considerably above the level of high water of spring tides.

North of Barnstaple the geological formation again changes to Devonian, the cliffs as far as Watchet, consisting of sandstones, limestones, grits, shales, and slates. Thence, along the southern shore of the Bristol Channel, the strata are new red sandstone, carboniferous limestone, Devonian beds, and patches of lias. Wastage has occurred in recent times between Burnham and Minehead. At Blue Anchor, between Watchet and Minehead, a sea wall was constructed in 1900 by the Somerset County Council for the protection of the high road, and

the Great Western Railway Company have had occasion to protect their railway from the inroads of the sea.

Large areas of low-lying marshlands have been reclaimed from the sea in the neighbourhood of Bridgewater and the river Parrett.

Generally speaking, the northern coast of Cornwall, Devon, and Somerset is as stable and exempt from serious erosion as any other littoral of similar extent in the country.

South Wales—Newport to Mumbles Head.—The north coast of the Bristol Channel, from the mouth of the Severn to beyond Cardiff, consists largely of alluvium brought down by the river, and considerable areas have been reclaimed from the sea in the neighbourhood of Newport. From Penarth to Lavernock Point the cliffs consist of Rhætic beds, the soft limestones, shales, and marls of which are slowly crumbling. Further west, as far as the mouth of the Ogmore, the formation is lias.

From the mouth of the river Ogmore to Swansea the coast is fringed with extensive sandhills or "burrows," largely of blown sand, rising in places to a height of over 200ft. The rivers Afon, Neath, and other streams flow through the sand deposit to the sea.

The flood tide in Swansea Bay sets in from the west past Mumbles Head, and an eddy tide from the eastward runs along the bay shore from the Scarweather shoal.

Mumbles Head to St. Bride's Bay—Fig. 19.—Mumbles Head, on the west side of Swansea Bay, and the cliffs westward to Worms Head, are of carboniferous limestone. Further west the geological formations are old red sandstone, carboniferous limestone, and coal measures as far as Kidwelly, with extensive deposits of blown sand in places. Land has been reclaimed from the sea in Burry Inlet and in the estuary of the Tavy, which flows into Caermarthen Bay. The cliffs on the south coast of Caermarthenshire and Pembrokeshire are of varied character, the principal formation being old red sandstone and carboniferous limestone. The south coast of Wales has suffered little from erosion in historic time, and only in isolated cases have landslides, cliff falls or denudation of beach led to any appreciable encroachment, and then only to slight extent.

Cardigan Bay.—The strata forming the cliffs throughout the whole of Cardigan Bay are of lower Palæozoic age, principally of the Cambrian and Ordovician systems. Igneous intrusions occur in places, notably in the neighbourhood of St. David's and Mumbles Head. In places the coast of the bay is fringed with sandy and shingle beaches, and numerous sandy estuaries exist, through which the streams flowing from the Cambrian Hills find their way to the sea. Some of these beaches have been subjected to local erosion, which has led to the construction of protective works where towns or considerable villages are situated close to the shore line, as at Borth and Criccieth. At Borth low groynes were constructed in 1899 to protect the village, which has been threatened by the inroads of the sea on the foreshore. On the coast between Aberdovey and Harlech, some groynes, constructed by the Cambrian Railway Company, exist to protect the coast section of their line; and at Criccieth groynes have been successful in protecting the sea wall to the south of the town and the cliffs on the north side of the harbour. At Port Madoc nearly 13 square miles of land have been reclaimed in the estuaries of the rivers Glaslyn and Dwyryd, and land has also been gained from the sea in the estuaries of the Dovey and Mawddach.

The flood tide sets into Cardigan Bay on the south from the south-west, and follows the coast line northward, which is the direction of littoral drift. On the north shore of the bay the drift is from west to east, the long reef known as "The Causeway," which runs out from the shore between Harlech and Barmouth in a south-west direction for over 11 miles, producing an eddy current in Tremadoc Bay.

The Lleyn Peninsula & Anglesey.—The cliffs throughout this section of the coast are of Archæan, Cambrian, Ordovician, and Silurian age, with patches of carboniferous limestone, old red sandstone, and igneous intrusions. At Pwllheli, near the south end of the Lleyn peninsula, extensive areas of marsh land have been drained in the estuaries of the Rid Hir and Erch, which flow into the harbour, and small tracts in Anglesey have likewise been reclaimed.

North Wales Coast—Fig. 20.—The strata forming the coast of North Wales are principally Silurian and carboniferous limestone, with coal measures on the west side of the Dee estuary. Extensive tracts of alluvium and blown and drifted sands occur at the mouths of the rivers Dee, Clwyd, and Conway, and marsh lands have been reclaimed at Conway, Rhyddlam, Rhyl, near Llandudno, Bychan, and in the Dee estuary. The set of the flood tide is from west to east, and the drift is in the same direction. The sand and shingle beaches on the coast line are being denuded in places, and, in consequence, groynes and other works have been constructed at Rhyl, Colwyn Bay, Penmaenmawr, and elsewhere to protect seaside resorts and the North Wales line of the London and North-Western Railway. The latter has been seriously threatened in recent years, and the company have expended large sums in protecting their property, which for miles runs close to the line of high water. In northerly and north-easterly gales, accompanied by high tides, broken water is frequently driven over the line and passing trains. Notwithstanding the loss of beach material which is taking place on this coast, large quantities are removed for sale at Rhyl and elsewhere.

The Dee and Mersey estuaries.—The estuaries of the Dee and Mersey are separated by the Wirral peninsula, and form at low tide wide expanses of sand banks, extending miles from the shore. About nine square miles of low-lying alluvial land, lying between Birkenhead, Wallasey, and Leasowe, at the northern end of the peninsula, were reclaimed from the sea in the early part of the last century. It is probable that this depression was formerly occupied by an outlet of the river Mersey.

Wastage occurs on the north shore of the Wirral peninsula between Wallasey and Hilbre Island, where the shore is skirted by low sand hills; no groynes exist, but protective walls have been constructed at Leasowe and Hoylake.

The Lancashire coast.—Almost the whole of the coast line of Lancashire consists of low sand hills or dunes, with broad sandy foreshores extending to considerable distances seaward of high-water mark. Shingle banks occur at intervals, and the continuity of the coast line is broken by the wide sandy estuaries of the Ribble, Wyre, Lune, Kent, Leven and Duddon.

On the shores of the Ribble estuary the sand dunes and

* No. V. appeared June 15th.

banks are increasing in extent, and many of the seaside towns on the coast are built on dunes or banks, the sites of which were at one time covered by the tide. At St. Annes the extension of the Ribble training walls has had the effect of shoaling the sea-bed and foreshore in front of the town to the extent of over 6ft. in recent years. Accretion is also in progress on the Southport shore and at Formby. Reclamation to the extent of over thirteen square miles has been effected in the Ribble estuary.

Between Blackpool and Rossall Point the physical conditions are not so favourable to the accretion of sand as on the coast line further south. The tidal stream sets from south to north along the Blackpool shore, and the littoral drift is in the same direction. Erosion is taking place along the entire shore line extending from Rossall Point, near Fleetwood, to south of Blackpool. At the latter place this action has been accelerated by the construction of the sea walls fronting the town. The promenade and walls now extend to a distance of nearly four miles, and over a quarter of a million has been expended on the construction of these works and protective groynes. The removal of large quantities of shingle from the foreshore, notably in front of the Rossall and Norbreck estates, for use in the construction of the walls at Blackpool, has had a most detrimental effect on the coast, and further abstraction between Rossall Point and the Blackpool boundary was prohibited by Board of Trade Order in April, 1905.

Groynes have been constructed at various points on the coast, but nowhere, except at Blackpool and Rossall, has any attempt been made to afford protection of this sort on a complete scale.

The geological formation of the coast between the Mersey and Morecambe Bay is new red sandstone overlain by glacial drift.

At Fleetwood, at the mouth of the river Wyre, the littoral drift is along shore from Rossall Point in an easterly direction. Groynes have been erected along the town frontage, and have been effective in collecting a large quantity of sand and shingle which otherwise would have worked round into the Wyre River.

The two tides which enter the Irish Channel—one on the north, between Rathlin Island and the Mull of Cantyre, and the other on the south, between Carnsore Point and St. David's Head—meet in Morecambe Bay, and in this neighbourhood the direction of littoral drift changes from northerly to southerly, following the set of the tidal stream.

The bay covers an area of about 150 square miles, and nearly the whole of it dries at low water. A considerable area of land has been reclaimed on the south side of the bay between Fleetwood and Lancaster, and the estuaries of the numerous rivers and streams which debouch into it would appear to afford opportunities for further reclamation works.

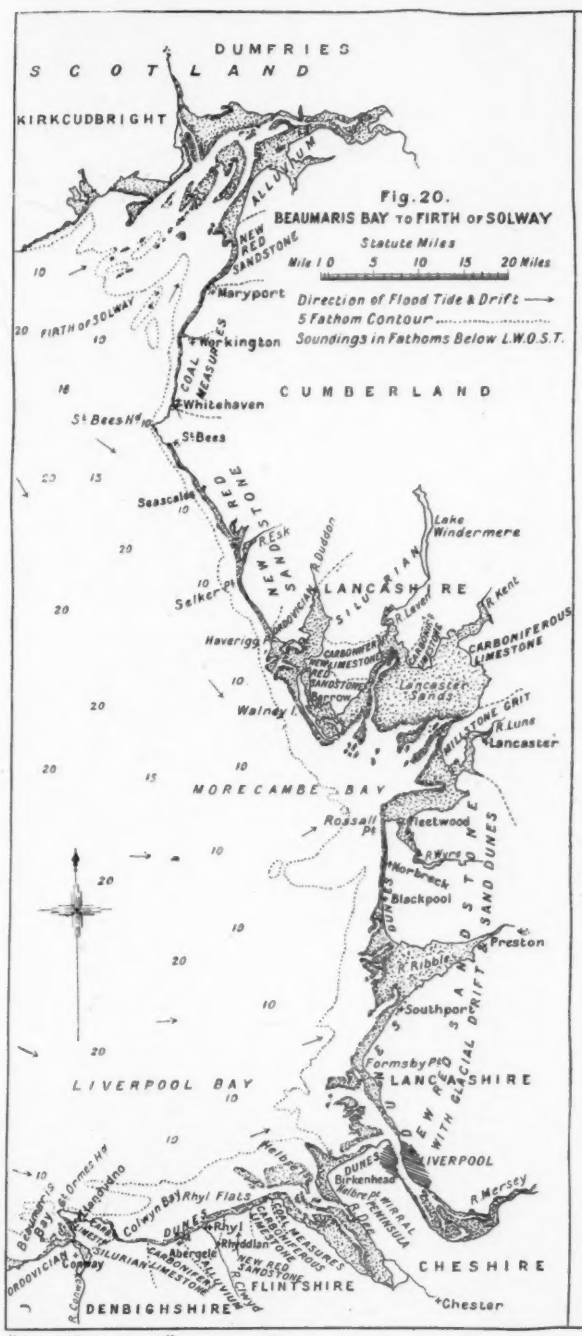
Morecambe Bay to the Solway Firth.—Walney Island, which extends from the northern side of Morecambe Bay to the Duddon estuary, is a long, low strip of land separated from the main at Barrow by a channel which at low water narrows to little more than 700ft. in width. The geological formation is glacial drift, and considerable erosion is taking place. The British Association report of 1895 gives the loss between 1852 and 1892 as 59ft. to 86ft. south of Earnsea Point, 720ft. near Trough Head, and 158ft. to 260ft. at the south end of the island. A few groynes have been constructed to protect the shore. One, at the extreme south-east end of the island, 700ft. in length, arrests the travel of shingle into the Piel Channel.

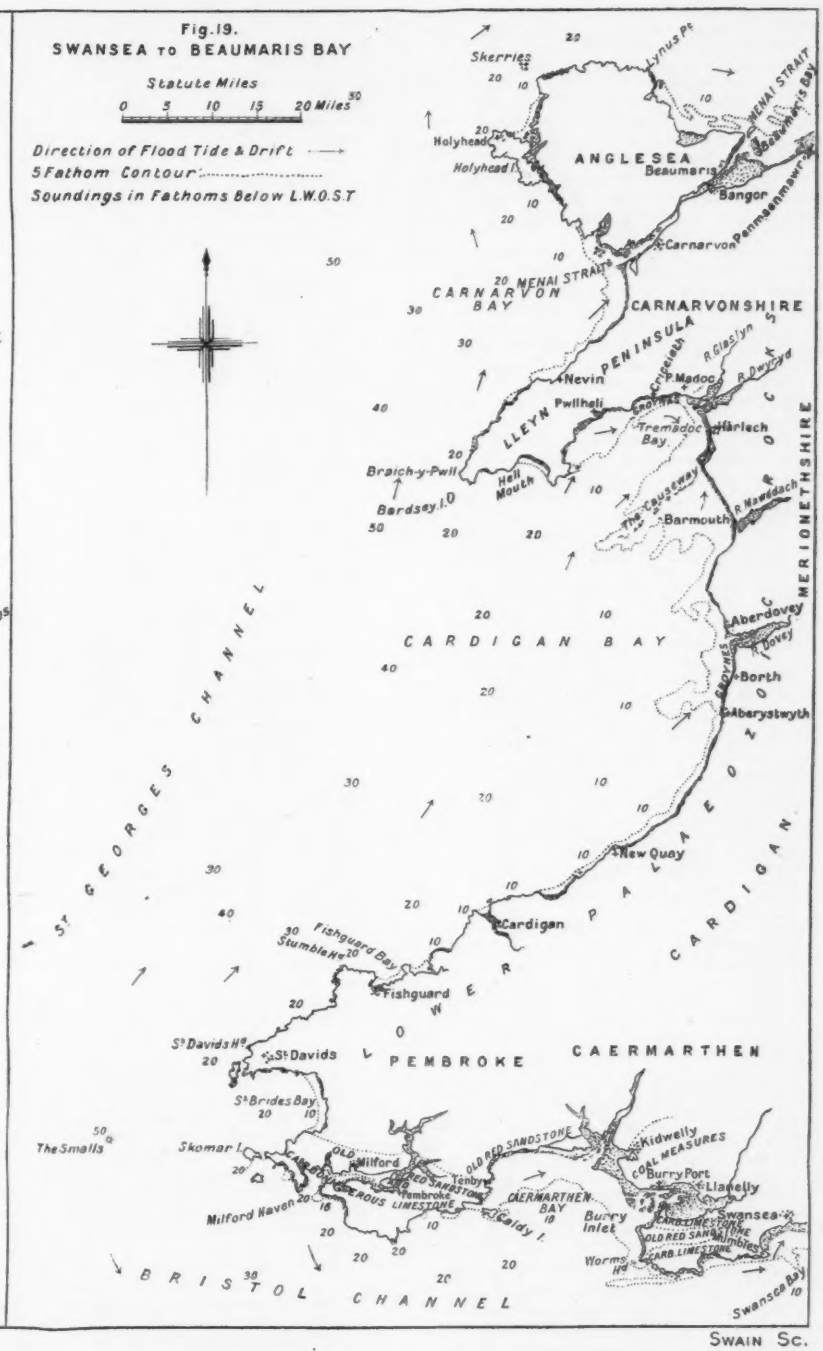
The Duddon estuary at low water is a wide expanse of sand banks, having an area of about 25 square miles, the shores being bordered by hills of blown sand. An area of over 200 acres has been reclaimed between Hodbarrow Point and Haverigg Point on the north side of the estuary, for the purpose of working the valuable iron ores lying beneath the sandy foreshore. An extension of the reclaimed area has only recently been completed.*

Between the Duddon estuary and St. Bees Head the geological formation is new red sandstone overlain by cliffs of glacial drift and boulder clay and long ranges of hills of blown sand. The new red sandstone beds form rocky ledges, locally known as "scars," in places extending seaward for a considerable distance from the cliff line. The beaches consist of sand and shingle, with boulders derived from the glacial cliffs and triassic beds. Erosion is taking place between St. Bees and Seascale, and more seriously further south between Selker Point and the Duddon estuary. St. Bees' Head is a bold promontory 310ft. in height consisting of hard conglomerate, limestone and sandstone beds. The coast to the north along the southern shore of the Solway Firth trends in a north-westerly direction. The geological formations generally are coal measures, Permian beds, and new red sandstone. The coast line is fringed in places with sand dunes, and in the Solway estuary the shore is bordered by wide sand banks which dry at low water. Erosion is of slight extent only on this coast, and practically no protection works exist.

The west coast of England is, from the physical character of the geological strata which form the land bordering on the sea, comparatively free from serious erosion. Where wastage has occurred to such an extent as to be of much consequence, it is due to the erosion of deposits of glacial drift, or geologically, recent alluvial deposits, and, in a few cases, of softer liassic and other strata. The coast line from the Land's End to Solway Firth is approximately 945 miles in extent, and the average recession in historic times cannot have been more than a few inches per annum.* In all probability the total loss during the past thousand years has not amounted to more than ten square miles, and this loss is far more than counterbalanced by the reclamation and accretion of land which has taken place during the same period.

Protection works of the description met with so frequently on the south and east coasts of England are few and far between, and exist only at seaside resorts, where the construction of sea or promenade walls has





"THE ENGINEER" SWAIN Sc.

* "Min. Proc. Inst. C.E." 1906, and THE ENGINEER.

* Sir Archibald Geikie is of opinion that the loss of land along the rocky western shore of Britain is perhaps not so much as one foot in a century.—"Text Book of Geology," 1903.

led to denudation of the foreshore, and where the value of the land is sufficiently enhanced by local circumstances to render protection profitable.

In some cases where the denudation of the foreshore has been accelerated by artificial removal of shingle, the evil has been minimised in recent years by the action of the Board of Trade in issuing prohibitory orders.*

Scotland.—The geological formation of the coast of Scotland is such that the erosive action of the sea is of little moment, except in a few localities of restricted area where estuarine deposits or sand dunes are being wasted. The strata throughout the whole of Scotland, with few exceptions, are of Palæozoic age, the rocks on the coast line consisting of hard shales, schist, limestone, and sandstone, with metamorphic and igneous patches. The loss of land may be measured at the rate of inches in a century.

Ireland.—The conditions obtaining in Scotland and on the south-west coast of England are found also in large measure in Ireland, where, except for a few localities on the south and east coast, there has been practically no appreciable erosion during historic times. The great central plateau of Ireland consists of carboniferous limestone, and extends from the coast in the counties of Dublin and Meath westward to Donegal Bay and Dingle Bay. In the north are large tracts of igneous and metamorphic rocks, while the east coast is principally Ordovician and Silurian. The south coast generally consists of old red sandstone, carboniferous shale and limestone, and Ordovician and Cambrian strata. Some protective works exist on the shores of sandy bays and estuaries, as in Dublin Bay, Dundalk Bay, Youghal Bay, and on the Wicklow coast, where the Dublin, Wicklow, and Wexford Railway Company has had occasion to protect its line in places where it runs close to the shore.

Relative extent of loss and gain of land.—We now come to the consideration of the extent of the land which has been reclaimed from the sea, or has accreted by natural processes, in comparison with the losses which we have briefly described in this and preceding articles.

We do not propose to extend the comparison beyond the coast of England and Wales, for reasons which are sufficiently apparent from our remarks concerning the geological formation of Scotland and Ireland. In making a tabular comparative statement we have estimated the loss and gain during the period of one thousand years since the beginning of the tenth century. This estimate is, of course, an approximation only; but it is based on a careful study of the facts and data available, and is probably as near the truth as such estimates can be. Let us, in the first place, summarise the losses which we have already described in some detail.

TABLE I.

Coast line.	Approximate length in miles.	Average recession of coast line per annum in feet (about).	Area lost in 1000 years A.D. 900 to 1900 in sq. miles (about).
Tweed to Tyne	60	1/5	1·0
Tyne to Tees	28	2/5	1·5
Tees to Flamborough Head...	59	2/5	2·2
Flamborough Head to Humber	45	5½	47·0
Humber to the Wash	45	2/5	1·7
Norfolk and Suffolk	120	under 7	150·0
Harwich to North Foreland...	82	5	77·5
North Foreland to Dungeness	50	4	38·0
Dungeness to Selsey Bill ...	90	4½	77·0
Selsey Bill to Portland Bill ...	102	3	58·5
Isle of Wight	72	under 3	40·1
Portland Bill to Exmouth ...	56	1½	16·0
Exmouth to Land's End ...	230	under 1/5	3·5
Land's End to Solway Firth...	945	under 1/5	10·0
	2008	mean 1·4	524·0

Note.—In the above table no deduction is made on account of land accreted or reclaimed in the several areas.

Table I. shows a total loss during one thousand years of approximately 524 square miles, or an average recession of about ·26 square miles per mile of coast, equivalent to an annual loss of under 1·4ft. It is to be observed that the average values given in the third column do not by any means represent the maximum rate of erosion in the particular district, or even throughout large sections of coast in a district. Thus, in the Harwich to North Foreland area the rate of erosion in places is very much greater than the figure given.

Table II. details the areas of accretion and reclamation formed in the corresponding period of time. Nearly the whole of the artificially reclaimed land now existing in England has been drained since the tenth century. A portion, however, was reclaimed in Roman times, and, so far as is possible, we have left such out of calculation except in the numerous instances, *e.g.*, parts of the Fenlands, when land drained by the Romans was subsequently allowed to relapse into its former flooded condition, and only recovered in modern time.

Of the total area shown by the table to have been gained from the sea, a portion only, about 80 miles, is land naturally accreted; the remainder has been embanked or otherwise drained by human agency. Such efforts have, however, in many instances been aided by natural deposition or "warping," as in the estuary of the Humber and in the Wash.

Serious as the loss of land has been on parts of the south and east coasts, the area gained artificially more than compensates for it. In the nature of things the natural accretion must be considerably less than the loss; but now, as in the past, it is quite possible to carry out reclamation schemes which will add largely to the present area of the country. Whether such reclamation is warranted from a financial point of view at the present time, in face of the low value of agricultural land, is a matter as to which there exists much diversity of opinion.

TABLE II.

Reclaimed and Accreted Land in England, A.D. 900 to 1900.

Locality.	Area in sq. miles.	Remarks.
Tweed to the Humber	46	Including Tees Estuary*
Humber to the Wash	815	Including Fenland,† Humber Estuary, Ancholme Level, Hatfield Level, Hull, &c.
Norfolk and Suffolk	36	Including Wells, Weybourne, Cley, Blakeney, Yarmouth, Lowestoft, Winterton, Blythe, Holkham, River Deven, River Stour, River Orwell, &c.
Harwich to North Foreland	100	Including Dovercourt to Walton, Thames Estuary, Whitstable, River Stour, Birchington, &c.
North Foreland to Winchelsea	75	Including Sandwich levels, Romney Marsh,‡ Dungeness Beach, Winchelsea, &c.
South Coast	15	Including Pevensey, Lewes levels, Newhaven, Lancing, Brading, Pagham, River Adur, River Arum, &c.
Land's End to Mersey	130	Including Bridgewater Bay levels, Burnham, Severn, Portmadoc, North Wales, and River Dee, &c.
Mersey to Solway...	60	Including River Mersey, River Ribble, Southport, River Duddon, Fleetwood, &c.
	1277	

* The area of reclamation in the Tees Estuary was stated in the third article of this series to be 10 square miles; this should have read "over 45 square miles."

† In making this estimate it is assumed that about 400 square miles of Fenlands were reclaimed in Roman times, and this area is not included in the total.

‡ Half of Romney Marsh is assumed to have been reclaimed in Roman times.

To those who suffer most by the erosive action of the devouring waves on our coasts, it can be little consolation to know that land can be gained from the sea in other and more favoured localities. If the report of the Royal Commission, which is about to consider the whole matter of coast erosion, results in any practical benefit to landowners and others who have suffered and are suffering, the labours of its members will not be in vain.

* Among such—including places on the South and East Coast of England—are orders applying to foreshores at Swanage (1896), Worthing, (1896), Lowestoft and Pakefield (1898, 1901), Walmer, (1898), Wells (1899), Borth (1899), Poole (1899), Seaford (1899), Bridgwater Bay (1903), Herne Bay (1904-6), Chichester (1904), and parts of Anglesey (1905). Several orders, applying to the South and East Coast of Ireland, have also been issued, and a few concerning Scottish foreshores.

WORKING OF THE SIMPLON TUNNEL.

(*By a Special Representative*).

THE ventilation of the Simplon Tunnel, although ordinary coal-burning locomotives are still in use, has proved a great success, and there are scores of short unventilated tunnels, down to one mile in length, where the condition of the air is far less satisfactory. In the Simplon the forced ventilation has also to subdue the natural rock heat. This heat is the only inconvenience passengers suffer. It is slight, and endures for a short portion of the journey, and it cannot be expected that electrical working will cause the least appreciable diminution of it. The ventilation is, in fact, admirable. Independent observers riding with the car windows open for the whole length of the tunnel testify to the purity of the air even in the most heated region, and the engine-men admit that there is no smoke or other inconvenience for them save the natural heat of the tunnel. The popular notion that the tunnel is badly ventilated is largely due to the action of the train conductors, who close the windows; but it appears difficult to persuade them to the contrary while passengers, with starting eyes, view the opening of a window as criminal. The benefits of artificial ventilation are lost when the entrance of the continually-renewed and fresh air is resisted. Riding with windows wide open all the way, particularly in the hygienic third-class vehicles, reveals the fact that the ventilation is, even with the steam locomotives, very perfect indeed, and leaves no condition to be desired other than the suppression of the moist hot-house heat towards the middle part of the tunnel; and this detail, of no consequence even to the least robust person, can never be overcome by any system of traction whatever.

The following notes upon the tunnel and its approach lines recall all the principal facts.

On the Italian side the route from Milan lies over the electrified line to Varese as far as Gallarate, thence to Sesto Calende, and *viâ* the new line from Arona to Domodossola. The maximum gradient is 1 in 166. The whole distance, Milan to Domodossola, is worked by steam locomotives and cars of the Italian State railways. From Domodossola northwards, at first over Italian territory, the line is operated by the Swiss Federal railways with Swiss rolling stock throughout. A change of cars is therefore usually necessary. Trains *de luxe* being a monopoly, are not considered here. Up to Iselle the prevailing gradient is 1 in 40.* For this service a new and very fine type of ten-wheel, eight-coupled—2·8—locomotive, by the Swiss locomotive works of Winterthur, is employed. Two of these powerful engines are required for a train of normal weight. The Italian trains are hauled when of moderate weight by one simple locomotive of the *ex* Rete Adriatica, series "No. 18 bis"—see page 320, October 2nd, 1903—or with heavy international trains by two of the old four-coupled engines of the *ex* Rete Mediterranea. Lying as it does along the shore of Lago Maggiore, station stops on this line occur at close intervals. On the Swiss side between the tunnel and Lausanne the maximum gradient is only 1 in 100, and over this section four-cylinder compound express locomotives—illustrated on page 309 March 27th, 1903—are employed. The stations for these various locomotives are at Brig and Domodossola.

* This line was fully described in THE ENGINEER, page 101, August 1st, 1902.

The tunnel was opened for regular traffic on June 1st. At present there are seven or eight passenger trains daily in each direction, besides a tri-weekly *train de luxe*. Goods trains do not at present appear to be very frequent. The line from Aigle—near St. Maurice, Switzerland—to Arona is single, but all Italian tunnels are built to accommodate double tracks.

The following notes relate to journeys made on June 9th:—Start from Domodossola at 2 p.m. with two "goods"-type locomotives heading the train. Temperature in cars 22½ deg. Cent. The helical tunnel at Varzo—3 kiloms. length—is entered at 2.24 p.m. with a rush. Temperature in this and the following straight tunnel of Trasquera rises from 23 deg. to 24 deg. Cent. Iselle station is reached at 2.33, or at an average rate of about 20 miles per hour. Here the pilot locomotive is discharged while the train engine fires up. With sidings included there are five roads in this station. Upon one stands electro-locomotor "No. 361," of the Tellina Valley Railway—*ex* R.A. type. The overhead wire equipment appears to be complete in the station. Start at 2.37, and entrance into long tunnel at 2.38. In a few seconds, in curved portion of tunnel, air is a little sulphurous, but soon becomes fresh, and continues so upon the up gradient, although the heat, after the fourth kilometre, increases. Five minutes later (2.43) the condensed vapour begins to run down the windows in those cars where they have been kept closed. The moisture in the outside air is palpable to the hand. At 2.44 the temperature in the closed-up compartments has risen to 25 deg. Cent., and at 2.47 increases to 25½ deg. Cent., the outside air meanwhile being pure and non-sulphurous. The station in the middle of the tunnel—visible by its numerous lights—is passed, and the falling grade then commences. Here the windows are pulled down, but despite the fresh cooling air then entering the cars, the temperature continues to mount to the ultimate maximum of 27 deg. Cent.—about 80 deg. Fah. The temperature then falls, at 2.58, to 25 deg. Cent.; at 3 p.m., to 24 deg. Cent.; at 3.2, to 22½ deg. Cent.; at 3.3, to 22 deg. Cent.; and at 3.4, to 21 deg. Cent. At 3.5 the train emerges by the north portal, and three minutes later reaches Brig Station, the speed in the tunnel having averaged about 28 miles per hour. The motion of the carriages in the tunnel is particularly smooth. The temperatures at the middle portion of the tunnel appear to vary—according to the train staff—very little, not exceeding 2 deg. Cent. under any condition of the outside atmosphere.

Outside the station at Brig four or five electromotors are seen standing in readiness. The return journey to Domodossola is commenced at 3.48 p.m. There are only nine cars in the train—eight six-wheeled and one double-bogie—drawn by an eight-coupled locomotive. The temperature inside the cars at Brig is 19½ deg. Cent.

At the north portal it is 20 deg. Cent., the tunnel is entered at 3.51. The car windows on both sides are kept open almost constantly. The temperatures noted are as follows:—At 4 p.m., 21 deg. Cent.; at 4.03, 21¾ deg. Cent.; at 4.5, 23¾ deg. Cent. The tunnel station is already passed at the summit of the line, and the air outside is now sensibly cooler to the hand, but the thermometer continues to record a slight increase of warmth: at 4.7 of 24 deg. Cent., and at 4.8 of 24½ deg. Cent. At 4.9½ the train leaves the tunnel, entering Iselle Station at 4.11. The speed in traversing the tunnel averaged 37½ miles per hour. The air was pure and entirely free from sulphurous gases and smoke throughout the whole length of the tunnel, although hot and damp in its mid-length. In this respect the observations of two independent observers in the same car concorded exactly with those of the driver of the train. As the windows were kept open the whole time on the falling grade, and almost constantly so on the rising grade, the travelling conditions were of the very best; the vitiated air usually generated in the car was absent, and no steaming of the windows occurred. At Iselle Station the car temperature remained at 24 deg. Cent., the outside temperature being much less. Thence, the temperature dropped continuously, being 23½ deg. Cent. in descending through the helical tunnel of Varzo—three kilometres in three minutes—23 deg. Cent. just below the tunnel, and 22½ deg. Cent. in Varzo Station.

These results were compared with the ventilation of the Gothard Tunnel on the following day, at about the same hour, in the direction Airolo to Goeschenen. The air in this latter case was noticeably cooler throughout, but in the first part of the tunnel the carriages were penetrated by a mildewy odour. For the greater part of the time the air passing by the carriages was pure, and at no time was it charged with sulphurous odour to any objectionable extent — the air, indeed, of our former "Metropolitan" used to be very much more so, while the vitiation of air in the present Paris Métropolitain is unquestionably still more serious, microbiologically. On the whole, the long Alpine tunnels provided with mechanical ventilation appear to furnish the best examples of aëration, although they are, of course, subject to occasional intervals of inferior results, due to greater frequency or volume of traffic, or to adverse outside meteorological conditions. In the Simplon, the line being single, no conflicting air currents can be set up by the crossing of trains such as, with steam locomotives, it is desirable to avoid to obtain the best ventilation.

UNDER the guidance of an English technical director, the Italian Government is now fitting out the San Bartolomeo yard at Spezia as a torpedo factory, where, under an arrangement with the Whitehead firm of Fiume, all the torpedoes required by the Italian navy will in future be manufactured, entailing, it is hoped, a considerable saving to the Italian naval estimates.

EGYPT IN 1905.

LORD CROMER'S annual report on Egypt in 1905 opens by a reference to the sale of his former report, and the fact that these reports are issued also in Arabic by a newspaper, *El-Mokattam*. That such an interest has been taken in these reports does not surprise us, for but a few days ago inquiries from Denmark on developments in Egypt were only the last of the tokens of the widely diffused sense of the work being done to give a new and larger life to that country, where not only East and West meet, but where the new promises to restore some of the glory of the old. Lord Cromer's extensive report helps us to witness the transformation, and it sets forth the annual tale of successful labour only too briefly, the air of business-like report by its modesty giving us little more than an outline of the work attempted and done. Even so, in this place it is impossible to do more than to refer briefly to points which may be regarded as of special interest to readers of THE ENGINEER.

Mining.—It is well known that much attention has been given of late to mining and its prospects in Egypt. A department has been organised, with its mining headquarters at Edfu. In the special report supplied by Mr. Wells, the director, a series of hints on the organisation and on the prospects of mining may be found. Lord Cromer is careful to point out that the Egyptian Government will not express an opinion on any particular venture. Still, the Government gives an indication of its judgment of the general position and prospects by constructing a track suitable for light motors between Edfu and the Red Sea, re-opening ancient wells, and making known its willingness to open out other lines of communication.

Some of the concessions now held have not given satisfaction, especially to the Egyptian Government. It is remarked that some, like Streeter's, covering a large area, have had but a small effort made to work them. On the other hand, it is clear that all the mining industry of Egypt so far is in the highly speculative stage. Ancient workings, indeed, abound; and we read of present efforts not wholly unrewarded. Two companies last year drew £E40,000 of gold; there are the emerald mines of the Red Sea littoral, deposits of nitrates and phosphates have been found between Assiout and the 28th parallel of north latitude, and in the Oases of Khargeh and Dakhleh, to the west of the river. Coal and oil, too, are, it is believed, to be found in Egypt. As to coal, it has been found, but not in commercial quantities; and it is felt that a better knowledge of geological features is required before a decided opinion can be given. Oil, too, is known to exist about Jebel Zeit, on the Red Sea; but in this matter also quantity is doubtful. Offers from prospectors, however, are being received, and this has led to the preparation of a new form of prospecting licence for all unleased lands.

"The general terms of this licence are: a yearly fee of £E25 per licence, which will permit the licensee to take up a prospecting area of 25 square miles, and, should coal or oil be found, the right to apply for and receive a concession not exceeding 10,000 acres for coal, and 5000 acres for oil, at a yearly rental per acre of P T 12½, with a royalty of P T 2½ per ton of coal, P T 2½ per hundred gallons of raw oil, and P T 15 per ton on mineral waxes or other substances included in the licence." This licence is now probably ready for issue.

The clause dealing with profits now in operation being felt to be unsatisfactory, a conference was held last summer in London between officials and various companies operating in Egypt. The matter has received a great deal of attention since then, but Mr. Wells can only say that so many points crop up that the committee then appointed cannot express a final decision, except that opinion is unanimous that while existing licences may have to remain under the present clause, new licences or leases should not be subject to the same conditions.

A hint already given will prepare the reader for the decision that no more exclusive prospective licences over large areas will be issued. General licences over unleased lands are under consideration, but these will be issued only for areas brought under control by lines of communication opened up from the Nile to mining centres. To lock up vast tracts of country by leasing to companies or individuals who do not, or cannot, fulfil an agreement is henceforth to be avoided; and the publication of standard terms for exploring licences is believed to be in the interest of the public, and has a regard for proper working conditions.

Finally, Mr. Wells ventures to express an opinion that the extent and distribution of minerals in Egypt warrant the expenditure of capital on their development; but he also thinks that it will take ten years to prove the commercial possibilities of the many mineral belts. Phosphates and nitrates for internal consumption seem to have considerable possibilities; and building stone of the Eastern Desert, which is of exceptional beauty in some cases, promises well also. Yearly reports of this department of Egyptian activity are projected in future, giving an account of the mines in operation, and of the prevailing economic conditions.

Irrigation.—Irrigation, of course, is a department of activity of great importance in Egypt, and the schemes in hand and those projected draw many besides idly curious eyes. During 1905, in June and July, the river levels were the lowest ever recorded, and Lord Cromer praises the way in which Mr. Webb and Mr. Macdonald controlled the discharge of water from the Assouan reservoir. But for that reservoir there would have been a loss of crop, and Lord Cromer thinks it impossible to over-estimate the benefits to Egypt from the Nile reservoir in 1905. In Lower Egypt alone there were 1,800,000 feddans under crop, requiring for a watering every twenty-one days a discharge of 47,000,000 cubic metres a day. From the Delta Canal system from May 1st to July 15th the average discharge was only 39,000,000, and it even fell to 34,000,000 cubic metres a day. The barrage at Assiout was closed throughout the flood, gates being dropped, and the water passed over the top of the upper shutters. Mr. Webb says there was no damage done to either the floor or talus, and remarks on the great benefits to Middle Egypt from this work. In Upper Egypt, owing to the low river, the work was of much difficulty, and it was feared there would be much "sharaki" (unirrigated) land. The late rise, however, and a skilful manipulation left an area rather less than in 1904 with a supply. The unwatered lands were on islands, and on the river foreshores, which cannot be protected in times of drought. The Province of Keneh, however, has benefited less than any others from the irrigation works of recent years; to remedy this the barrage at Esneh is to be constructed. This barrage is intended at first to raise the river level only, so that north of it lands may get waters even when the river is low. When the summer supply of Egypt has been settled, the design will permit the barrage to be raised, and used for a "sefi" barrage, like those at Assiout, the Delta, and Zifta. It is estimated that the barrage at Esneh will cost £1,000,000, and it will be commenced at once by Sir John Aird and Sons.

Mention of the Assouan Dam recalls to mind the postponement of raising its height. Lord Cromer evidently wishes to emphasise the reasons for that, with a purpose which becomes quite plain. Some mathematicians of repute had doubted whether the calculations of the stresses and the stability of the masonry dams had covered a range sufficiently wide. It appears that the discussion of that question is going forward still, and a very definite conclusion has not been reached. The other reason for postponing the raising was the decision to construct a masonry apron to protect the rock from the water issuing from the dam sluices. Progress has been made, and it is satisfactory. The holes and depressions caused by the rush were filled with solid granite masonry, set in cement mortar, up to the level of the sills of the sluices, and carried down an easy gradient to the rock surface 60 m. down stream from the dam. Granite blocks embedded 0·40 m. deep in the rock form the face work. Since August water has been flowing at a high velocity over these works, and with the exception of one spot, where the face work was badly jointed, the work has stood the test excellently. The remainder of this protection work will be finished this year. Lord Cromer then adds a warning against the rumours, promulgated occasionally, that the dam is not stable. Very few, it appears to him, are qualified to form an opinion; but among those few not an individual can be found without entire confidence in the stability of the dam.

Some facts concerning the objects aimed at in constructing the dam at Assouan and the barrage at Assiout are thus given. They were constructed, not so much to bring fresh land under cultivation as to give an assured supply to the Deltaic provinces and to convert the lands of Middle Egypt from a system of basin to perennial irrigation. The first object has been accomplished to the utmost capacity of the reservoir, but the conversion in Middle Egypt may take two or three years before it is completed. This work is proving more costly than was expected, and partly from the success of the other works the cost of labour has risen; contract prices have increased 60 per cent. in the last three years. The Ghizeh conversion works will, therefore, cost about £E500,000 more than the original estimate. Lord Cromer adds a number of illustrations showing the results economically of the reservoir and other subsidiary works. We can give only one or two. The Bahr Nazlah district in the Fayoum, a tract of 20,000 acres brought under cultivation; it was hitherto unirrigated and untaxed, but at, say, £E20 an acre, it may be valued at £E400,000. The Government looks for a revenue of £E1, or £20,000 from these lands. In the Kodah, Rubiyat, and Tanyeh villages an area of 43,848 acres, valued in 1898 at from £E10 to £E15 per acre, is now worth from £E30 to £E40 per acre, or an aggregate increase of £E1,000,000.

On the projects of the Upper Nile Lord Cromer refers to the special report by Sir Wm. Garstin, which he appends. The Soudan-Egyptian Irrigation Service was formed in December, 1904. Mr. Dupuis was placed at the head of it, and a vote of £E24,000 was placed to its credit in the estimates of 1905. Lord Cromer is of opinion the development of the Soudan and of Egypt will depend largely on the decisions which will be taken as these survey parties report, and the ultimate decisions upon them. So far the work has not proceeded much beyond organisation, but Sir Wm. Garstin thinks an excellent start has been made. The work aims at first at the collection of information for the study of projects, for the increase of the water supply of Egypt, and for the irrigation of the Soudan upon a regular and comprehensive system. Problems are intricate, and the collection of data will take years, probably, to acquire. The area is vast, the climate unhealthy, and there is difficulty connected with labour, transport, and supply. In addition to the survey and levelling, a series of discharge measurements of the river and its affluents has to be made. Gauges to register water levels have to be erected, and houses for the staff built. The Governor-General of the Soudan, Sir Francis Wingate, and his staff, are co-operating generously, and there is hope that, in addition to the work done in 1905, by the end of 1906 much progress in obtaining information will be recorded. Hoped, let it be said; but the two steamers ordered from England for this irrigation service were lost in a barge carrying the portions of these boats to Wadi Halfa, near Naga Hamadi Bridge, during the flood. Other steamers are now under construction, but the loss means six months of hampering, and the work must suffer for this working season.

Some of the work done by Mr. Dupuis and his staff in 1905 should be of much interest in this connection. One of his parties surveyed near Kassala, on the Abyssinian border, studying the irrigation of lands bordering on the river Gash. Works were commenced during the year, intended as part of a whole, this portion to irrigate some 10,000 acres, and to cost £E20,000. Other three parties surveyed the Gezireh, the tongue of land between the White and Blue Niles. A party also carried a line of levels and a rough survey across the country from Sobat to Bor, far up the White Nile, as it has been proposed to cut a new channel for the Nile between these points, and so to avoid the great swamps. Mr. Dupuis and Captain Wilson, of the Soudan Civil Service, rode across this country in February of last year, to obtain an idea of its nature. A level, grass and bush covered plain, sparsely inhabited, liable to inundations in the rains, but free from swamps, and almost waterless during the dry months. Supplies and water failing, the survey party turned back after completing about one-third of the distance. To state, therefore, what the slope of the country may prove to be is yet impossible. So far as they go the levels show a slope from south to north of about 7 centimetres per kilometre. To level right across is the task of the current season. The same party carried up a line of levels from Taufikia to Sir B. Baker's old station on the White Nile to a point about 70 kilometres up the Bahr-el-Zaraf.

From the work done in the Gezireh last year Mr. Dupuis concludes that a great canal for irrigation there is a feasible work. Two lines of levels were drawn, the one up the Blue Nile to Famaka, on the Abyssinian frontier, the other up the White Nile to Gozabu-Goma, and from this last place a check line to connect the two was thrown across to Sennar. The work would be costly, as Mr. Dupuis believes the river would have to be taken off far south near Karkoj, and a barrage constructed on the Blue Nile itself. There is also a project for a reservoir at the Roseires Cataract, and a certain amount of study was given to it; but as this is not an urgent matter, and requires much further study, it was not pursued far. Since the work summarised above, done before the rainy season, the parties went out again in November, but their work cannot be recorded yet.

Masonry gauges have been erected at points on both rivers, such as Mongalla, Bor, and Taufikia on the White, and Roseires on the Blue Nile. It is hoped that in good time masonry gauges will be placed at every necessary point upon the two branches. Regarding the discharge measurements of the two rivers and their tributaries some good work was done, as Mr. Tottenham went in the Sudd region, and obtained a very complete series of observations in the Bahr-el-Gebel during the last year's flood. Mr. Grieve also visited the Settei River on the frontier of Abyssinia. The Inspector-General of Irrigation, Mr. Dupuis, has dealt with some important matters, in consultation with the Soudan Government, such as regulations for water-lifting appliances in the Soudan, and other points, concerning irrigation in that country. At Khartoum the house and offices in erection are making good progress; the health of the staff, with one exception of mental derangement, was excellent.

Labour being scarce in these remote regions, all proposals for work up the White Nile involve the use of special dredging plant. In Canada and the United States attention has had to be given to the construction of powerful hydraulic dredgers, and so Sir William Garstin obtained the consent of the Egyptian Government to depute Mr. Dupuis to visit these countries and to study the different types of dredgers in use. He did so last year in the autumn, and his report will be submitted to the Government shortly. It is not surprising that Sir William Garstin should add that Mr. Dupuis and his staff have a right to congratulate themselves upon their work. To us at home this enterprise looks like a page from a fairy tale, and the more the wonder grows as we reflect on the history—the recent history of these regions in the Nile basin.

Railways.—On State railways there are some highly interesting chapters and reports of Lord Cromer, Sir Charles Scotter, and Mr. Trevethick. The subject is known to be a somewhat sore one. In a vigorous chapter Lord Cromer refers to the system in the past as in a very unsatisfactory state; but he pleads that the individuals who formed the Railway Board were not responsible for it; the system had been imposed on Egypt by the accidents of the political situation. The signature of the Anglo-French Convention in 1904 made it possible to sweep away the cumbersome system, and to inaugurate an era of real improvement. Lord Cromer promises the £E3,000,000 which Lord Farrer's Commission thought should be devoted to improve the railways within the next few years; but he thinks that some time must elapse before such a large sum can be spent to advantage. He refers with great pleasure to the report of Sir Charles Scotter, confirming his own opinion that the present staff is fully able to cope with the administration of the railways. Figures are given to indicate the course of affairs during the past few years as follow:—

	1902	1903	1904	1905
	£E	£E	£E	£E
Net earnings	1,059,000	1,064,000	1,233,000	1,327,000
Capital expenditure	351,000	419,000	414,000	647,000

The impression made is thus quite encouraging; the earnings for the past four years represent about 14 per cent. on the capital laid out—£E1,860,000—during that interval.

Three years ago the navigation dues on the Nile were abolished. It was foreseen that the net earnings of the railways might diminish, and the Railway Administration endeavoured to recoup by developing the passenger traffic. Success has attended the effort. The number carried in 1903 was 14,952,000; in 1904, 17,725,000; and in 1905, 20,014,000. The receipts from passenger traffic in those years were: £E996,000, £E1,118,000, and £E1,313,000 respectively. Omitting fuel, the contracts for railway material for 1905 were placed: in Great Britain, £E450,000; Belgium, £E215,300; Germany, £E86,400; France, £E20,000; Russia, £E3600; Sweden, £E2887; and purchased locally, £E53,500. Orders for Great Britain, after limited competition generally, were for locomotives, carriages, wagons, rails and accessories, signalling material, telegraph material, creosoted wooden sleepers, machinery, paints, &c. &c. The orders for

Belgium included wagons, bridge and roofing material, fish-plates, bolts, nuts for rails, spare parts for locomotives, &c. From Germany the orders were almost entirely for locomotives and their accessories. The French orders were for oils, machinery, and screws.

Mr. Gunn, the Government Inspector, speaks hopefully of the prospects of the light railways as a whole. Of two, the Delta Company and the Basse-Egypte, he gives a satisfactory account, but regards the Fayoum Company, as working unsatisfactorily. This last company has now been bought by an Anglo-Belgium Company. Mr. Gunn regards the prospect for such light lines as very hopeful, and is of opinion that there is plenty of scope for them, as well as for the Government railways. They are all working up to the limit of their rolling stock, and boats also on the waterways are doing a large business. As the Egyptian agricultural roads are not metalled, Mr. Gunn observes how these lines are used increasingly to communicate between districts and provinces.

Mr. F. H. Trevethick, the chief mechanical engineer to the Railway Administration, supplies a highly interesting report on the British, Austrian, German, and American locomotives tried in Egypt. Having tested 20 British and American engines over 137,000 miles each up to December, 1905, he has registered on the consumption of oil, engines on repair, and the cost of maintenance, &c.

	Oil.	Repairs.	Total.
	£	£	£
British	134	753	887
American	128	830	958

In 1901 Neilson's—now the North British Locomotive Company—supplied the Egyptian Administration with 10 engines, and Henschel, of Cassel, 15 engines, and the Staatseisenbahn, of Vienna, 10 engines, in 1902. These 35 engines were to the same design, kept in the same depôt, and did similar work. Up to the end of the year they had run an average of 120,000 miles, and passed through the shops for first repairs. The result of comparison is as follows :—

	Coal.	Oil.	Repairs.	Total.
	£	£	£	£
British	2271	117	660	3048
German	2290	108	685	3083
Austrian	2362	105	708	3175

Spread over three years, Mr. Trevethick thinks the difference in maintenance is very small. The distance which these engines ran before entering for repairs, and the coal consumption in pounds per mile, were :—

	Miles.	lb.
British	59,684	37·02
German	59,804	37·12
Austrian	52,519	38·66

The drivers have shown no preference for one make, and so Mr. Trevethick thinks there is little to choose between British and German engines in hauling and steaming capacity. The initial cost of each engine was: British, £3245; German, £2917; and Austrian, £2935. For working cost and maintenance the three makes are, Mr. Trevethick thinks, practically the same, the difference in favour of the British being balanced by the larger initial cost. The British finish is better studied, however, than the others, and, in his opinion, well worth paying for. Mr. Trevethick enters into some detail in regard to the tubes for coal economisers, and comes to the same conclusion—the finish, at an extra cost, would lead him to choose the British make. He adds some very interesting figures showing how Neilson and Henschel are now able to produce engines much more expeditiously than in 1901, the time required being in favour of Henschel now; but it is hinted that much might depend upon the state of the respective order books. Firms seem to be realising now the importance of quick delivery.

At the present moment we cannot do more than refer again to Sir Chas. Scotter's important memorandum on the organisation and working of the railways in Egypt. His draft of the Supreme Council, the various appellations, the suggestion of an uniform gauge obviating two classes of railway stock, all are matters touched with a firm but kindly hand, and his report will be regarded long as an important State paper in Egypt. We may later on be able to sketch this paper at greater length.

Of the works at the ports of Alexandria and Port Said, of the bridges over the Nile now building, of the public buildings in hand and under consideration; of the water supply of towns, and the plans for waterworks which are preparing for Zagazig, Menouf, Mehalla-el-Koubra, Zifteh, and Mit Ghamr, our space to-day will not permit us to treat. Nor can we find room for some information given of the work done in the technical department of the educational work. We can only add that this bulky document is teeming with points of interest to all who follow human activities, and our summary will show how engineering in various departments is of service, and will be of service, in a renovated and prosperous Egypt.

HIGH POWER STEAM ENGINES AT BERLIN.

SIDE by side with steam turbines of recent construction in the Berlin central stations there are reciprocating engines varying in size from 3000, 5000, to 6500 horse-power, which represent the highest excellence in this type of engine, working with an economy such as is likely to reduce to a very small margin the sum total balance in favour of the steam turbine. For the time being, the installation of the latter is probably of too recent origin to permit of a decision; but the future installations of the Berlin Power Company will undoubtedly prove which type has been found most advantageous, all points considered.

As examples of reciprocating engines, those illustrated on page 625, and in our two-page Supplement, have a very high reputation on the Continent, and if they do not hold their own against the "steam mill," it would be difficult to find other steam engines that could. One of the larger sized engines — 5000 to 6500 horse-power—is installed, together with a high-power turbine, at the Oberspree central power station, and the other is at the Moabit central station. The latter, built by the firm of Sulzer, of Winterthur and Ludwigshafen, is placed side by side with four other engines of 3000 to 4350 horse-power, built by the same firm. These two stations in the northern suburbs of Berlin are the most important of the Berliner Elektricitaets-Werke, which supplies all the power to the Great Berlin Tramways Company, and for public services and lighting.

The general view on page 625 represents all the engines of Sulzer build at the Moabit station, the 5000 horse-power engine being right in the background, and the drawings in our two-page Supplement show the engines at the Oberspree station, which were built by the Goerlitzer Maschinenbau-Anstalt of Goerlitz. The two larger-sized engines conform very closely in general design, the main difference being that while the valve gears of the Swiss engine are of the well-known Sulzer type, those of the Goerlitzer machine are of the Goerlitz system on all cylinders, except the high-pressure, whereon the Collman expansion gearing is employed. All valves are of quadruple drop-seat pattern above and below the cylinders, and are operated by trips. The Goerlitz valves are illustrated in the sectional drawings, while the Winterthur pattern is well known and is the same in all the engines from 3000 to 5000 horse-power at the Moabit station.

Each engine is a four-cylinder or double-tandem engine, working with triple expansion, the two low-pressure cylinders being placed forward nearest the engine shaft. Nominally of the same power, the cylinder dimensions of the 5000 horse-power engines are slightly different, as follows :—

	Goerlitz (Oberspree station).	Winterthur (Moabit station).
High-pressure	40½in.	40in.
Intermediate	60½in.	60½in.
Low-pressure	72½in.	72½in.
Piston stroke	67in.	67in.

The working speed is 83 revolutions per minute. The initial steam pressure for the Goerlitz engine is 183·7 lb. per square inch, and for the Winterthur engine it is 176·4 lb., but in each case it is superheated. At a given cut-off the power developed is approximately the same in each. In the Goerlitz engine, at 11 per cent. cut-off, the I.H.P. is 2920 and E.H.P. 2540; at 22 per cent. I.H.P. is 4580 and E.H.P. 4060; at 28 per cent. I.H.P. is 5300 and E.H.P. 4760; and at 50 per cent. admission in both engines the I.H.P. is 6500 and E.H.P. 6000. Both engines are fitted with the Hartung spring governor, the larger Winterthur engines differing in this from the smaller engines of Sulzer make, which, as is visible in the engraving on page 625, are supplied with Porter governors. The differences of detail between the 3000 and 5000 horse-power Sulzer engines lie chiefly in the greatly increased size and a more complete enclosing of the reciprocating and revolving parts. The large Goerlitz and Sulzer engines are practically enclosed except at the crank chamber. The open side of the cylindrical cross-head guide, or frame, is closed by panels of thick bent glass having the same contour as the frame. The arms of the fly-wheels are also enclosed by plates of sheet metal. No tail-rods are fitted to the pistons of the 3000 horse-power Sulzer engines, but support for the heavy pistons of the larger engines has been provided at three points on each rod independently of the pistons themselves. In the 3000 horse-power engines a pedestal bracket supports the piston-rod midway between the tandem cylinders, it being cast in one with the gland chamber and foundation saddle which unites the two cylinders. In the 5000 horse-power Sulzer engine this pedestal bracket has been replaced by a projecting bracket on the three rearmost cylinder covers in such a way than these bearings leave little of the rod's length unsupported between the tandem cylinders, while that part of the tail extension left unsupported by the rear bracket works in a guard tube.

Steam jackets and jacketed ends are provided in all engines described, save for their high-pressure cylinders, which are not jacketed. The superheated steam is conveyed to the high-pressure valve chests in an iron pipe passing beneath the cylinder casing. Each cylinder is a separate casting, and there are, of course, separate liners. In all the Sulzer engines the front cylinder covers are cast solid with the external cylinder and its jacket and valve chests, the rear covers alone being separate pieces. But in the Goerlitzer engine all cylinder covers (jacketed) are separate pieces, and externally the cylinders have a different aspect by reason of the receivers being carried in almost unbroken line along the top of the cylinders, so as almost to conceal the valve chests, the large domes of which are so characteristic of the Sulzer machines. In these latter the tandem piston-rod is in one piece, and to dismantle the engines the rear cylinder covers—H.P. and M.—are first unbolted, and the pistons unscrewed. The low-pressure pistons are then pulled through the back ends of their cylinders, unscrewed, and the tandem piston-rod pulled away through the front cylinder covers until the low-pressure piston is free to be lifted out between the cylinders.

As will be seen from the drawings, the Goerlitzer engine differs in most of these details. While in the Sulzer engine the chamber connecting the cylinders is rather shorter in length than the piston stroke, in the Goerlitzer this free space is almost double the piston stroke. As a consequence, the support for the heavy piston-rod and pistons is differently arranged, there being, besides the main-rod crosshead, a slide-block between and behind the tandem cylinders, the guide-bars therefor being supported by pedestal brackets. The tandem rods are composed of two parts keyed together at the central bearing. They are forged with a slight camber, and turned up on a specially adapted lathe, the initial curvature of the rods disappearing under the weight of the pistons when in place, these latter practically floating in the cylinder liners—an arrangement that should materially reduce unequal wear; the ringsare of Ramsbottom pattern. All rubbing surfaces in the various engines described are capable of fine adjustment to obviate bending or torsional strains consequent upon wear, the slippers of the crosshead slides being regulatable in the guides; the crossheads are carried in pivotal slides, and in the Sulzer engine the bracket supports for the piston-rods out beyond the cylinder covers have a universal movement, so that they may adapt themselves to the momentary alignment of the piston-rod. Expansion and contraction due to temperature in the body of the engine, and in the steam pipes connected to it, have also been carefully studied to avoid setting up detrimental strains, and the connections of the feet cast on the tandem connecting chamber and on the ends of the rearmost cylinder, with the foundation curbing anchored to the sides of the engine pits, are contrived to allow of free expansion longitudinally.

The large orifice in the cylinder connecting chamber is not stayed in the 3000 horse-power engines, but in the 5000 horse-power machines two heavy longitudinal tie bolts are employed to brace this opening against any possible deformation. In the Sulzer engine these bolts are close together, but in the Goerlitzer engine they are spaced widely apart.

The valve gear shafts of the larger engines are driven from the fly-wheel shaft through worm gearing of steel and bronze in order to ensure a perfect mesh. In the older 3000 horse-power engines bevel gearing is employed. The countershaft for the expansion gear—Collman—in the high-pressure admission valves is driven from spur-gearing on the main valve shafts, which latter is extended back to the mid lengths of the high-pressure cylinder, where, through worm-gearing, it drives the vertical spindle of the Hartung governor.

From the exhaust valves below the steam passes to the intermediate receiver and to the steam jackets, its pressure there being regulated so as not to exceed 78·5 lb. per square inch. The exhaust from each low-pressure cylinder has its own condenser, the horizontal double-acting air pumps being placed in the pits below each extremity of the engine shaft, and worked by connecting-rods attached to the crank pin.

Each engine has a starting engine driving a wheel-train, gearing with a toothed rim bolted to the fly-wheel on the high-pressure side.

The engine shafts are bored out hollow. The journal diameter of the Goerlitzer engine is 26½in., the fly-wheel seat is 31½in., and the piece weighs, cranks and pins included, 30 tons. The Sulzer journals have an equal bearing area, differently proportioned, and the fly-wheel seat is 33½in. in diameter. The engines are all coupled to alternators, the revolving fields of which are carried on the rims of the fly-wheels, the inclusive weight being 110 tons in the case of the highest power engines. By reason of the trussed-bar construction of the armature frame this latter only weighs 50 tons exclusive of the pedestals, the latter weighing together 24 tons; or a total weight for the whole alternator, so composed, of 184 tons.

With the engine developing 6000 horse-power at 83 revolutions the three-phase current generated is 4700 kilowatts at 6000 volts. The momentum of the mass in motion being 3,800,000 kilogrammetres, the possibilities of speed variation are reduced to a very low value.

All minor details for the control of the engines are planned so as to give the least inconvenience to the attendants. The valves—stop and regulator—for the admission, steam and vacuum gauges, handles for the blow-off cocks and preliminary warming of the jackets, are grouped together between the cylinders, so that in starting the attendant can readily observe every movement from the same standpoint.

The engines are kept in splendid running trim, and the hall, although devoid of architectural embellishments, is maintained in excellent order.

In the boiler-house adjoining, this standard is, by reason of the quality of the coal consumed, not quite in keeping. The boilers are of the water-tube type, by Steinmüller, Babcock and Wilcox, and Borsig.

Our acknowledgments are due to Mr. Karl Wilkens, of the Berliner Electrical Company, for his very courteous assistance and facilities for inspection he afforded our representative.

THE INSTITUTION OF MINING ENGINEERS.

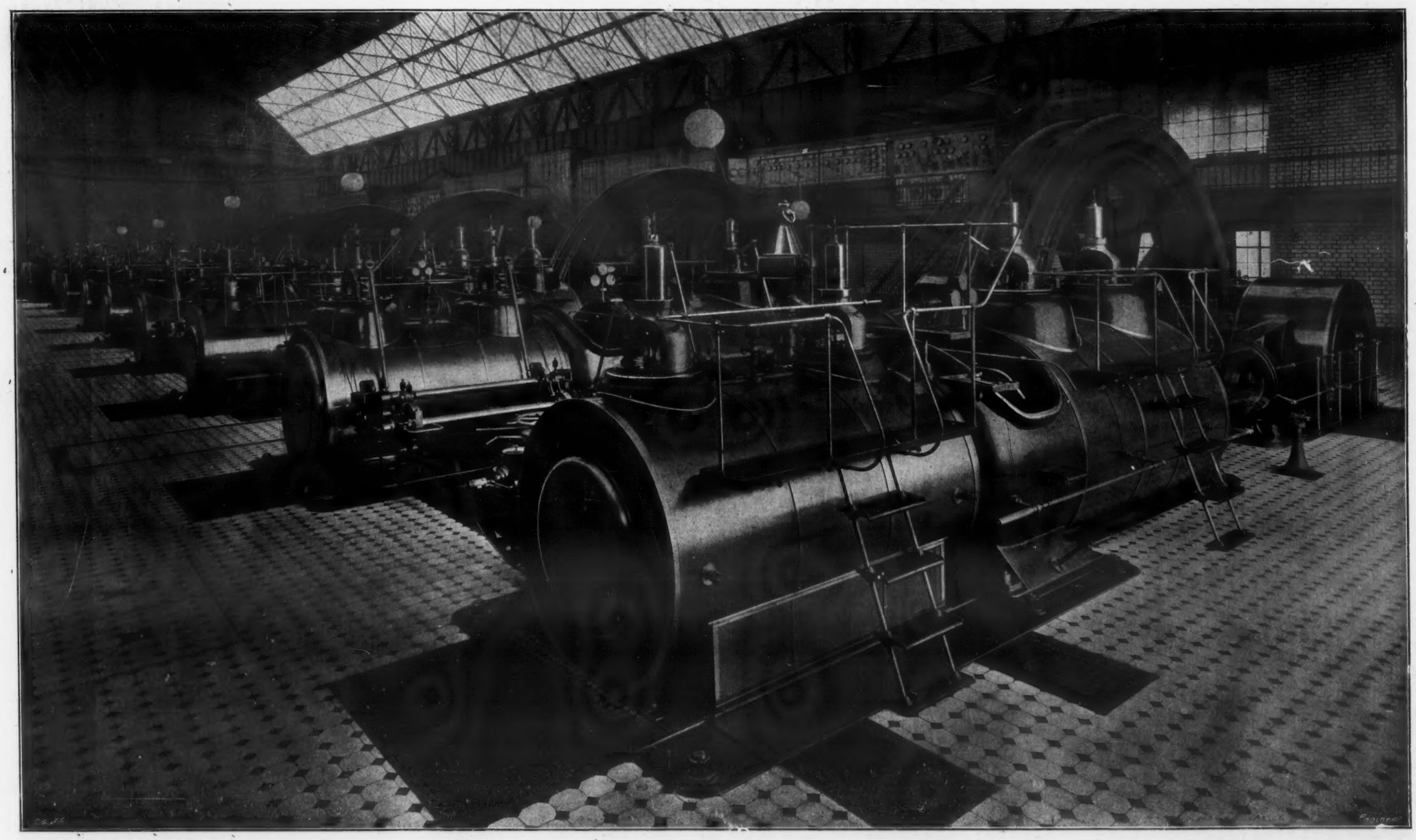
THIS Institution held its fifty-fourth general meeting in the rooms of the Geological Society, with an overflow meeting at the Royal Astronomical Society, on Thursday and Friday, 14th and 15th inst. Thirteen papers were down for reading, and ten others open for discussion. Mr. W. C. Mountain again set forth his views on the "Commercial Possibilities of Electric Winding for Main Shaft and Auxiliary Work," and regards it as quite possible, if current can be supplied from a central station to a group of collieries, that the electric energy can be produced at such a low price that it may pay to spend more money on the winding gear and to adopt electricity for every conceivable purpose throughout the pit. Under these circumstances electric winding will have a fair chance, but where heavy winding is to be done at a single colliery, and the winding absorbs probably two or three times as much power as the rest of the machinery, and is also only running, say, eight to ten hours per day, there can be no doubt that it is almost impossible to compete with high-class steam engines.

Mr. A. Thompson pointed out that "Electrically-driven Air-compressors" can be applied with advantage in some cases, even if not so economical from the point of view of steam consumption. The motors used in his case are duplicate compound-wound motors of 90 horse-power, made by the British Thomson-Houston Company, Limited, running at 550 revolutions per minute, and wound for a pressure of 500 volts. The electric current is conducted from the generator to the shaft bottom by 37/12

ENGINES AND GENERATORS AT THE MOABIT CENTRAL STATION, BERLIN

GEBRUDER SULZER, WINTERTHUR, ENGINEER

(For description see page 624.)



vulcanised india-rubber insulated cables of the 2500 megohms grade. The cables after leaving the shaft are carried in 1¼in. insulated conduiting to a distribution house situated near by. From here 37/13 mains are carried to the junction-box, where 37/14 cables are taken to each air compressor. The cables are suspended by yarn from the rolleyway timber. The underground mains are all of vulcanised india-rubber of the 600 megohms grade, the high degree of insulation being maintained by periodical covering with bituminastic paint. One lot of averages taken showed:—Ampères 160, volts 550, 118 electrical horse-power actually leaving the switchboard at the generator; and of this 90 horse-power is developed at the air compressor: consequently the efficiency is 76 per cent.—that is, 76 per cent. of the horse-power leaving the switchboard is given out effectively in compressed air. The efficiency of the air-compressing plant, under those conditions, would be 62 per cent., from steam to the indicated horse-power of the compressed air, but the plant is not yet working at its best, the load factor being only 30 per cent., and there is no condensing plant. These motors were set to work an Alley-Maclellan air compressor of the single-cylinder type, and an Ingersoll-Sergeant air compressor of the duplex-cylinder type. In the latter the two cylinders are each 14¼in. in diameter by 12in. stroke, and at a speed of 150 revolutions per minute the output is 633 cubic feet of free air per minute. In the former the cylinder is 14in. in diameter by 18in. stroke, and with 140 revolutions per minute the output is 350 cubic feet of free air per minute. These were employed on coal cutting with an Ingersoll heading machine; in the Alley-Maclellan district the cost per ton was 1s. 11·61d., as compared with 2s. 4·5d. when worked by hand labour. In the Ingersoll-Sergeant district the machine-getting cost 2s. 7·95d. per ton, the hand-getting 3s. 3·15d.

Mr. Sam Mavor reviewed the "Practical Problems of Machine-mining," alluding to the advantages of coal-cutters; the types of coal-cutters; the mode of laying off the machine face, for the length of this face 750ft. being regarded as a maximum; the depth of the under cut, 3ft. to 3½ft., being considered shallow for use in bad roof and floor, 4½ft. to 6ft. in deep cutting, and 3½ft. to 4½ft. medium; the position of cut; the gate roads, the advantage of having them every 15ft. or so in a 3ft. seam being emphasised. Also cross-gates, explosives, conveyors at the coal face, the management of the face, timbering, manipulating the machine, rails, and skids; compressed air and electrically-driven cutters, the efficiency of the latter is taken at 60 to 65 per cent. compared with the former at 20 per cent. of the power exerted in the steam cylinder of the compressing engine. The power compressed and various other conditions are considered, making the whole a comprehensive review of this phase of coal mining. Especially significant just now is the employment of conveyors at the coal face. Some figures relating to fuel consumption are as follows:—

Fuel Consumption of Coal Cutting Machines.

Type of plant.	Nature of holing.	Fuel used per square yard cut.	Thickness of seam.	Proportion of fuel used to output.
		Lb.	In.	Per cent.
Electric plant used for general purposes	Hard fire-clay	2·8	48	0·10
Electric plant used for coal-cutting only; compound engine, lightly loaded	Coal	17·9	32	1·00
Electric plant used for coal-cutting only; compound engine	Fire-clay ...	7·3	28	0·47
Compressed air plant used for coal cutting only; non-compound engine	Fire-clay ...	52·0	28	3·30
Compressed air plant used for coal cutting only; non-compound engine	Fire-clay ...	30·0	20	2·70
Compressed air plant used for coal cutting only; compound condensing engine	Fire clay ...	23·0	22	1·90
Compressed air plant; type of engine not stated	Coal	51·0	57	2·30

Professor Henry Louis has tested the "Strength of Brazed Joints in Steel Wires," and finds that both brazed joints and short scarf-brazed joints are much weaker than the wire, but that long scarf-brazed joints are at least as strong as the wire when it has become softened by the heating; whilst electric welds are just a little weaker than brazes. The wire should be hardened and toughened, so called "patented," after brazing or welding.

Mr. J. A. Roelofsen, in an odd way, connected Liebig's aversion to the use of ammonium sulphate as a manure, and Dr. Perkin's discovery of coal tar dyes with coke making, and then describes the Haessener coke ovens.

Mr. George Farmer, in his "Considerations on Deep Mining," repeated various things that have already been said on the subject.

Mr. G. A. Meyer, manager of the Shamrock Mine, Herne, Westphalia, read a paper in English on the "Rescue Apparatus, and the Experiences gained therewith at the Courrières Collieries by the German Rescue Party." The paper was illustrated by excellent diagrams of the mine and of the apparatus employed, whilst an actual equipment was also shown. The paper attracted much attention. The apparatus is used without any helmet, and consists of two sets of appliances—one carried in front, and the other at the back of the bearer. In one a supply of compressed oxygen is contained in two cylinders, one for the outward, and the other for the return journey. The other set of appliances contains the purifying appliances, breathing bag, and relief valve. The gases pass from the mouth into a corrugated pipe, and enter a bag made of india-rubber hanging on the breast of the wearer. This bag contains in its uppermost portion another india-rubber bag, having an intake opening, to which the breathing tube coming from the mouth is connected, as well as several exhaust openings. This bag also contains the sheet tin vessel in which granulated caustic potash is piled loosely in numerous chambers, so that it must be traversed in all directions by the expired gases; 2·2 lb. of caustic potash will supply the apparatus for a period of two hours. In the lower part of the absorption vessel and in sundry tubes there is a quantity of kieselguhr to absorb the moisture from the exhaled air. The apparatus carried on the back includes the two oxygen bottles with common shut-down valve, pressure-gauge, reducing valve, safety valve, injector and moisture separator, all contained in a knapsack, in the cover of which there is a thick glass plate for viewing the pressure gauge. The exhaled air is removed from the region of the mouth by an injector, and another injector serves for charging it with fresh oxygen after it is purified. These are the main features of the apparatus that proved so successful in the explorations at the Courrières mines. Mr. Meyer described the character of the reserve station and its equipment, and emphasised the need of keeping it in good order, and of having a corps of men always trained in the use of the appliances. He explained the condition of the Courrières mines after the explosion, and expressed the opinion that it was a coal-dust explosion. Many speakers took part in the discussion, and complimented Mr. Meyer on his exposition of this important and interesting subject. One speaker thought the apparatus too complicated. Mr. Garforth described an apparatus of his own of a similar kind which has been found efficient, which appeared to be more complex, but the man bearing it was told to crawl under a table giving a passage of only 19in., and did it. Mr. Garforth sounded a note of warning in pointing out that such apparatus were scarcely applicable for prolonged operations.

Mr. Wm. Maurice drew attention to "A Rateau Exhaust Steam-driven Three phase Haulage Plant." The plant comprised an accumulator containing 50 tons of scrap-iron pit-rails, assembled horizontally and in parallel layers with associated main stop valve, turbine valve, and throttle valve; an eight disc turbine, and with it an exhaust pipe, injector condenser, and a direct-acting pump to the hot-well. It only uses part of the exhaust steam of the winding engine, and when that is not running can work on live steam. Owing to the arrangement of valves and an automatic relief valve, there is no appreciable change in the speed of the turbine when fed with steam from any of the three sources—that is, exhaust, live, or regenerated steam. The plant serves a road hauling 1000 tons in 6 hours at a speed of 4000 yards an hour, with a total pull of 7936 lb., requiring 47 horse-power and two other haulages, making the whole demand on it 91 horse-power. This work is done by an A. E. G. 60 horse-power induction motor, capable of giving 100 horse-power per hour without undue heating. The power plant consumes 203 Board of Trade units, and the underground lighting 27 units, as recorded daily on a watt-meter.

Allowing 10 per cent. depreciation of plant and 5s. per day for labour, the cost per unit is 1·3d. when working only 250 days per annum. If the turbine ran 250 days per annum on the full load the cost per unit would be reduced to 0·55d. without allowing for the saving that would result from the consequent stoppage of another boiler. If it were possible to have a permanent night load all the year round, the cost, instead of falling again, would rise slightly, since the plant would run two-thirds of its time on reduced live steam, and would require to have charged to it a proportion of the boiler expenses.

Mr. J. B. Tyrrell related the various arrangements introduced to overcome the difficulties in a perpetually frozen and out-of-the-way region in course of the "Development of Placer Gold Mining in the Klondike District, Canada."

"The Education of Mining Engineers," "The Capacity Current, and its Effect on Leakage Indication in Three-phase Electrical Power Service," and "Petroleum Occurrences in the Orange River Colony," formed the subjects of the other three papers.

LONDON COUNTY COUNCIL ELECTRIC SUPPLY BILL.

No. VII.*

WHEN the Committee met on Thursday, last week, there only remained to be heard a speech by Sir Ralph Littler, K.C., on behalf of the City Corporation, before Mr. Freeman was called upon to reply to the whole of the case against the Bill. The opposition of the City Corporation did not seem to rest on any very sure ground, except that the Corporation might have to contribute towards any deficit that was made, and that its option to purchase the undertakings of the companies supplying in the City might be prejudiced.

Mr. Freeman, in his reply, dealt mainly with the broad principles affecting the Bill, preferring to treat most of the opposition as clause opposition, to be dealt with, if necessary, later. He said there had been two rival theories—the one enunciated by the Administrative Company, and the other by the local authorities, which he thought were mutually self-destructive. There had also been a third, viz., that put forward by the electric lighting companies of London, which was really an attitude of *non possumus*. Everyone agreed that the broad principle of such a scheme as this was consideration for the consumer, and if the present electric supply authorities could not give the necessary supply in a cheap enough manner, then it followed almost without question that some other authority must. The difference between the Administrative Company and the London County Council in this matter was that whereas the latter only proposed to supply to authorised distributors, with but a few exceptions, the Administrative Company by their Bill would be able to supply direct to power users, with the consent of the authorised distributor, subject to an appeal to the Board of Trade. At this point a good deal of cross-questioning took place by the Committee, and particularly on the part of the Chairman on the question of whether any loss by reason of previous capital expenditure on the part of any local authority should be borne by the consumer or the ratepayer. In other words, the case was assumed that a local authority has erected works, and is generating at such a cost that the London County Council could offer current at such a price that it would pay that particular authority to shut down the works, so far as generation is concerned, and take the whole of its supply from the Council. Then came the question as to the capital cost incurred, and who should bear the capital and interest charges. It cannot be said that Mr. Freeman was quite prepared to meet the point, for he first argued that, as the original money was borrowed on the security of the rates, the rates should bear the loss. The Committee did not quite follow, however, and Mr. Freeman explained it in this way, that the profit made by taking energy from the Council—compared with the original cost of generation—would be so great as to enable such a local authority to pay off its debt charges, and still give the consumer some benefit, whilst, as a last resort, he said that it was almost inconceivable that anyone would be working under such uneconomical conditions as to warrant shutting down its generating plant, and that the object of the London County Council scheme was for existing undertakers to generate up to the point at which it became uneconomical, and then to purchase from the Council. At least one member of the Committee favoured the idea that the Council should take over any such liability itself.

Dealing with the opposition of the Administrative Company, Mr. Freeman said he thought his best answer to this was that as there were so many of the richest company promoters in London willing to find money for a power scheme, it could not be the riskily speculative venture that the company would have the Committee believe. As far as he could judge, the whole difference, from Mr. Merz' point of view, between a company and a municipality, was that the latter was not so well able to canvass as a company. But in this particular case the London County Council did not desire to do anything of the sort, because they did not propose to supply to the consumer direct, as did the company.

Mr. Freeman, dealing briefly with the opposition of the electric lighting companies, ridiculed the practicability of the linking-up scheme proposed, in view of the various conditions as to periodicity and voltage under which they worked. Further, he entirely disagreed with Mr. Balfour Browne that an electric lighting Provisional Order gave a monopoly to the holder; the Act distinctly stated the contrary. He believed that the true object of the linking-up scheme was to render it practically impossible for the purchase clause being put into effect. In conclusion, he urged that the Bill should be passed, if possible, this year, as the waste of another twelve-month was a most serious matter for the trader of London—a point upon which even the promoters and the opponents were agreed.

The Committee sat again on Tuesday to hear certain evidence from gentlemen who had asked to be allowed to appear before them. These gentlemen turned out to be Mr. Arnold Lupton, M.P., Mr. W. H. Booth, and Mr. B. H. Thwaite, who conjointly had formulated a scheme for giving an electric power supply to London, of which the following is an outline as given by Mr. Lupton. In the first place, Mr. Lupton enlarged on the advantages of his scheme for getting rid, in a large degree, of the smoke nuisance in London. He proposed to use a current of 60,000 volts, and the generating station, which could be erected 120 miles from London, would be equipped with machinery with a capacity of 1,000,000 kilowatts. A ton of coal used at the coalfields for generating purposes would be equivalent to four tons burned in open grates from the heating point of view. His intention was to use gas engines and producer gas, by which the same amount of energy could be produced for half the quantity of coal as compared with steam engines. Cheap slack coal would be used, and he estimated that the sale of the by-products would reduce the cost by 2s. 6d. per ton. In order to supply 104,000 kilowatts in London it would be necessary to equip the station with 120,000 kilowatts of plant, and the cost of transmitting that energy to London would be £82,095, whereas, allowing 3lb. of coal per unit, the cost of carriage of the coal would be £107,500. With stations in London the coal cost increased with the load factor, whereas with the increase of the load factor on a station at the pit's mouth, the cost of transmission remained stationary. His intention was to erect his plant in Nottinghamshire, within a 10-mile radius of the coalfields, the capacity of the station being, as already stated, 120,000 kilowatts. The cost of land and buildings he put at £2,310,000, and transformer cables, &c., at £1,170,000, a total capital cost of £3,480,000. The loss in transmission he put at 10 per cent., and the loss in transformation at 6 per cent. The overhead wires would be carried on single wooden poles, each carrying 25,000 kilowatts. This scheme would have a saving in capital cost of £120,000, as compared with the London County Council scheme or that of the Administrative Company, and he was prepared to embody his proposals in a Bill and form a company to carry them out. The transmission poles, he said, would be 50ft., high with 6ft. transverse supports, the poles being placed twenty-five to one mile. It was proposed to erect them by the roadside for the most part.

Mr. Lupton went into very elaborate detail, but it is unnecessary to give more than the bare outline, as it was perfectly clear that the Committee hardly took the scheme seriously. Mr. Booth and Mr. Thwaite both gave evidence in support. The former stated that gas power was very much more efficient than steam from the thermo-dynamic standpoint. The overall efficiency of a steam plant was 12½ per cent. or 13 per cent. on a steady load, against 25 per cent. for gas engines; in fact, he had obtained an efficiency of 31 per cent. with gas engines. He estimated that if the London County Council burned 300,000 tons of coal per annum it would create 13,500 tons of sulphuric acid, which would be discharged into the atmosphere. Of course, there would be some reduction by the fact that less sulphur would be discharged by small works which took up electric driving, but he had made no calculation. In answer to some rather caustic questions by Mr. Freeman, witness admitted that he had never carried out a large electrical scheme in Great Britain, but he had studied very closely the experience of American engineers, and thought no harm would be done by

* No. VI. appeared June 15th.

following them. He would only propose to supply authorised distributors in bulk and not supply individual consumers. It would also be possible to supply persons along the route of the mains, but he had not gone into that very fully.

Mr. B. H. Thwaite, in giving similar evidence, said he also had had no practical experience of the nature outlined in this scheme. The largest gas engines at work in this country were 750 horse-power machines. He estimated that energy would be delivered in bulk for ·249d. per unit on a 35 per cent. load factor. He first thought of a scheme for supplying London with electric power in 1892, and it had been in his mind ever since.

The last of the independent "experts" who had asked to be called was a Mr. William Doig, who said he attended as "a member of the public," and who made the wonderful suggestion that electricity should be purchaseable at $\frac{1}{5}$d. per unit, and that a special Government department should be created to undertake the business of electric supply.

Mr. Hammond was then recalled and dealt briefly with the scheme put forward by Messrs. Lupton, Booth, and Thwaites. He said he had considered the proposals, and even he and Mr. Merz agreed that they were unworkable. The great transmission schemes referred to as precedents existed under very different conditions to those obtaining here—viz., there was water for practically nothing at one end and exceptionally dear coal at the other. In this case he thought that even if coal were 1s. per ton at one end and 9s. 6d. at the other, this difference would not cover the extra costs entailed by a station erected on the coalfields. The costs, in his opinion, would be greater both as regards capital expenditure and working expenses. As to the proposal to carry the cables overhead in the manner suggested, he ridiculed the proposition. One circuit only should be carried on one pole, and not as proposed, 25,000 kilowatts. Further, it was a curious fact that the bulk of the energy used from Niagara was taken within one mile from the works—*i.e.*, people found it cheaper to move their factories near to the generating station rather than to stay at the end of a long transmission line.

The Committee visited Greenwich generating station on Wednesday. Yesterday (Thursday) evidence from the Board of Trade was heard, and only the decision remains now to be given.

DOCKYARD NOTES.

STAGE one of the Manœuvres has ended, and now everyone is wondering what they were all about, and many are trying to guess with more or less accuracy. Briefly, the idea was that we were on the verge of war, which would be precipitated by the first hostile act of an enemy seeking to compensate nautical inferiority by a bolt from the blue. The enemy prepared his bolt something on the lines of the Japanese torpedo attack on the Russian fleet at Port Arthur, and his destroyers proceeded towards Gibraltar with that end in view. Unfortunately for them, they were observed by a Red division, which, faced with the obvious intention, promptly made mincemeat of the would-be attackers.

THE German battleship "R," of the Deutschland class, has been launched and named Schlesien. The 11,000-ton cruiser, sister to the recently launched Scharnhorst, has been named Gneisenau.

IT has been decided to put the one-break day on trial for a year at Portsmouth Dockyard. From July 2nd the workmen's hours will be for the first four days of the week from 7 to 12 and from 1.30 to 5; on Fridays they will break at 12, but resume work at 12.45 and continue to 4.45, and on Saturdays the day will end at noon. The week has thus forty-eight hours. There is very little doubt that a plan which has proved eminently successful practically wherever it has been tried will be accepted as the rule when the year of trial is up.

A RUMOUR that the floating dock is to be brought from Bermuda to assist in the salvage of the Montagu is absolutely without foundation.

THE ROYAL SHOW.—The Royal Agricultural Society's annual exhibition of live stock, farm implements, &c., will open at Derby on Wednesday next. It is extremely gratifying to note that, in respect of entries in the implement section, there is a very large increase over the last two shows at Park Royal. The number of stands at Derby will be 424, compared with 289 and 350 at Park Royal in 1905 and 1904 respectively. The live stock section also shows a marked increase. The show will remain open until Saturday, June 30th. The trials of suction gas producers was held this week.

TIN MINING, which is the principal industry in Bolivia, and which is certainly that which offers the best prospects, is progressing much better than would be expected, considering the enormous difficulties that all engaged in the business have to contend with. The lack of facilities in transport is, perhaps, the worst, and not a little less felt is the scarcity of labour, which, as new mines are worked, becomes more accentuated. The former may, perhaps, be overcome by the projected railways, but the latter will remain a problem until such measures are taken as will bring out a sufficient number of emigrants.

GRIMSBY INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—On Saturday, the 16th inst., by invitation of the Orient S.N. Company, Limited, a party of about 100 members and their lady friends visited the R.M.S. Ophir, which was lying in Grimsby Roads prior to proceeding on her first voyage of this season to Norway. The vessel was thoroughly inspected, the magnificent saloons, state rooms, and other passenger accommodation being much admired by the whole company. The gentlemen of the party also inspected the engines, boilers, refrigerating machinery, &c., where they found much of particular interest to them.

SOCIETY OF ARTS.—The Council of the Society of Arts have awarded the Society's silver medal to the following readers of papers during the session just completed:—Mr. W. F. Mitchell, "The Commerce and Industries of Japan;" Dr. William Arthur Aikin, "Aspect of Voice Development;" Mr. Leon Gaster, A.M.I.E.E., "Progress in Electric Lighting;" Mr. Walter Garstang, M.A., "The Fisheries of the North Sea;" Captain G. S. C. Swinton, "London Traffic;" Mr. Bernard B. Redwood, B.A., "Motor Boats;" Mr. J. B. Millett, "Submarine Signalling;" Professor Thomas Oliver, M.A., M.D., LL.D., "Bridge Building by Means of Caissons;" Mr. Clayton Beadle, "Watermarking;" Sir James A. Bourdillon, K.C.S.I., "The Partition of Bengal;" Dr. George A. Grierson, C.I.E., "The Languages of India;" Colonel Sir Arthur Henry McMahon, K.C.I.E., C.S.I., "Seistan;" the Hon. Rodolphe Lemieux, K.C., "French Canada;" the Hon. J. G. Jenkins, "Social Conditions in Australia;" Mr. Louis N. Parker, "Historical Pageants;" Mr. H. Yates Thomson, F.S.A., "Illuminated Manuscripts;" Mr. Harry Powell, "Cut Glass."

SUCTION GAS PRODUCER TRIALS.

No. II.*

Messrs. Crossley Brothers, Limited, of Openshaw, Manchester, are exhibiting two complete plants, each set being of different design. The gas producers are illustrated in Figs. 7, 8, and 9. The second of the two, Fig. 8, is practically the firm's standard apparatus; there is, however, one slight deviation from the usual design, which consists in having a combined coke and sawdust scrubber. This is rather a new departure in suction gas plant practice. We are given to understand that it has proved satisfactory in practice, the gas distributed to the engine being very clean. It has been found in some cases that the gas has not been perfectly cleaned by a coke scrubber, and, in consequence, dust carried forward into the cylinder of the gas engine has caused rapid deterioration of the working surfaces. This plant is well known, and it is unnecessary for us to go into further particulars of the details of it here.

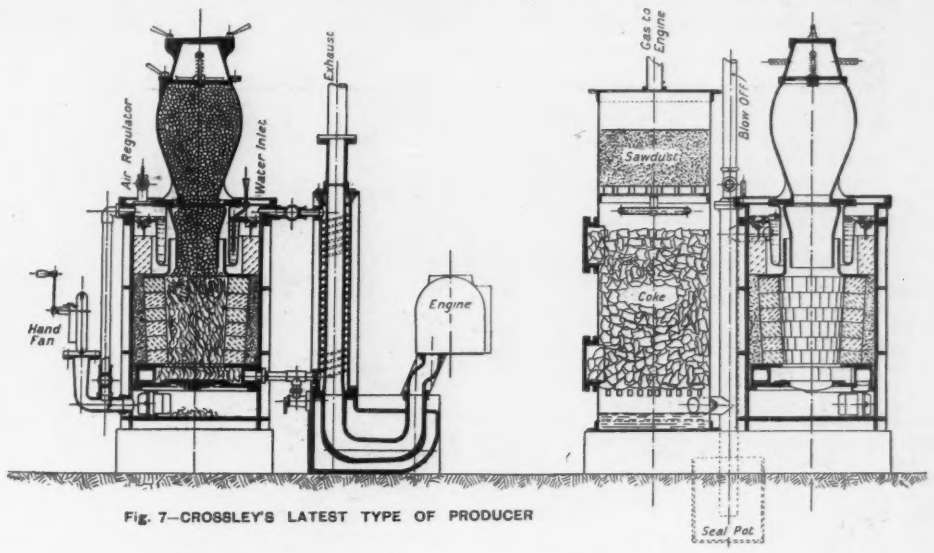


Fig. 7—CROSSLEY'S LATEST TYPE OF PRODUCER

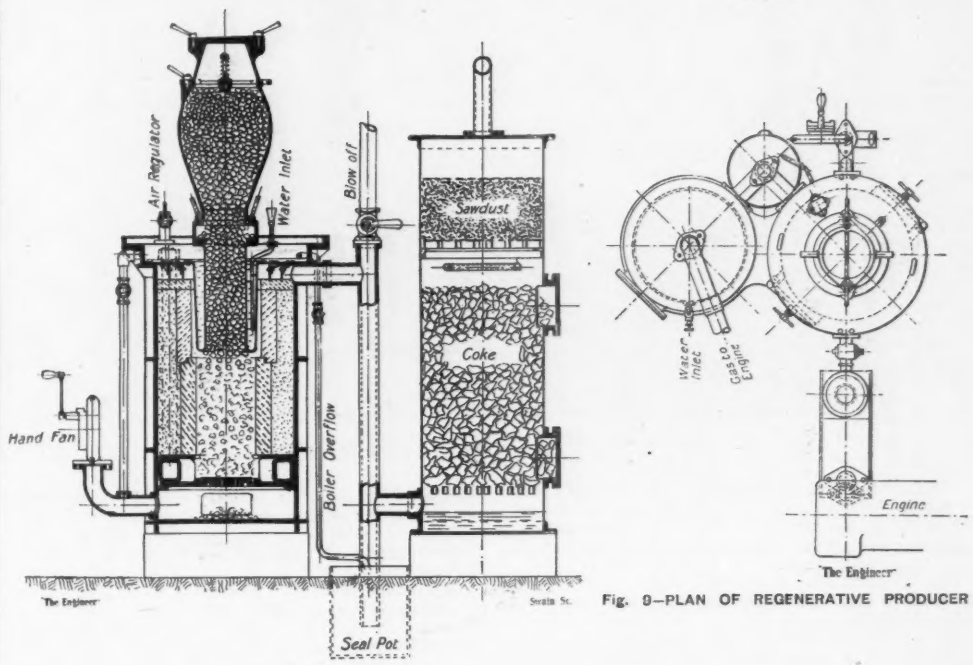


Fig. 8 Fig. 9—PLAN OF REGENERATIVE PRODUCER

The second plant—Fig. 7 and 9—contains several innovations, the most important one being the utilisation of the heat from the exhaust gases of the engine for heating the mixture of steam and air on its way to the generator. This regeneration is said not only to increase the economy in working, but also to improve the combustion generally, clinker being reduced. It will also be noticed that the gas leaving the producer is made to

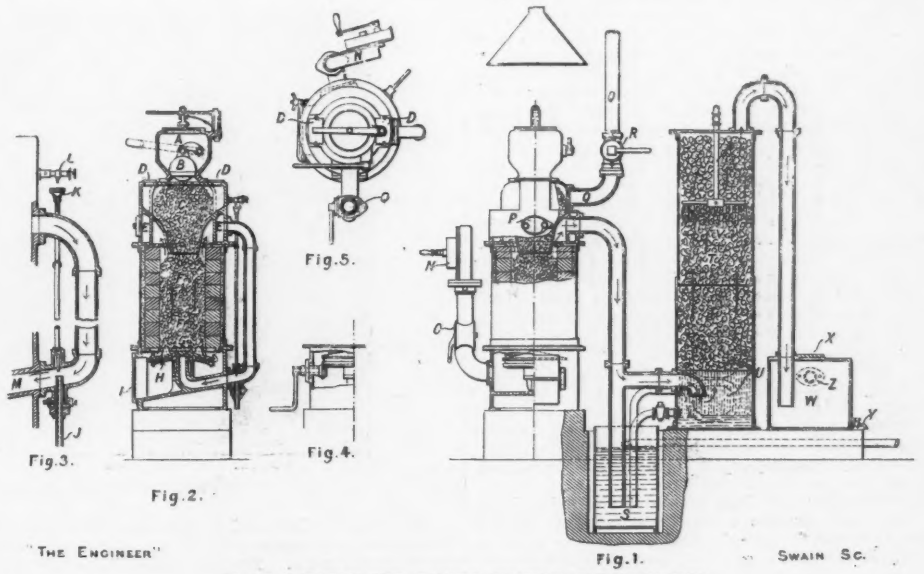


Fig. 10—FIELDING AND PLATT'S SUCTION GAS PRODUCER

* No. I. appeared June 15th.

circulate round a coal storage bell before passing to the heating surface of the steam boiler. The result is that the heat present in the gases leaving the producer is comparatively small, with consequent efficiency of regeneration and economy. The boilers are constructed entirely of steel with welded joints, and it is claimed that by this means quick steam raising is obtained, and the plant is very sensitive on variable loads, taking large variations without trouble or independent regulation. It is also claimed that all the steam raised in both types of plant is obtained solely through the heat of the gases after the actual gas producing stage. This firm is of opinion that any heat taken from the fire in any other way is not economical.

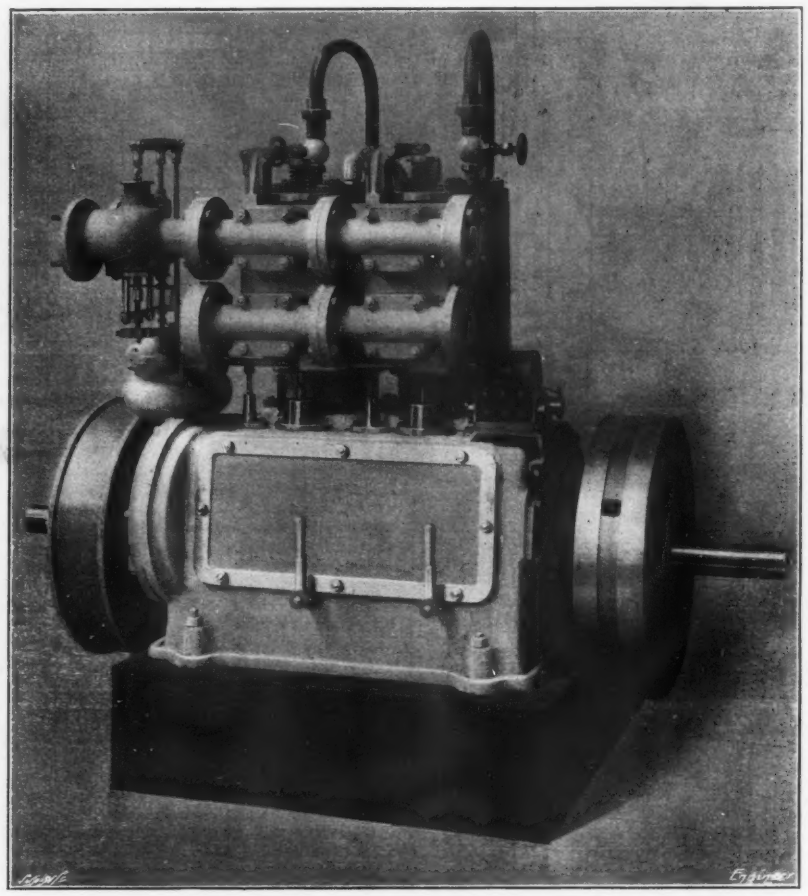


Fig. 11—HINDLEY'S HIGH SPEED 20 B.H.P. GAS ENGINE

The Fielding suction gas plant, which we illustrate in Fig. 10, is distinguished by two important features from other systems in use. In the first place, there is no boiler for the storage of either water or steam, but an equivalent to a flash boiler is used, which takes the form of a double circular conical base, upon which the fire rests; the circular base consists of a gear wheel upon which is bolted an upper plate having ribs cast upon its lower side. The air enters at the centre and spreads radially, carrying with it the water in spray form, the air is highly heated, the water is converted into superheated steam, and both enter the fire uniformly around the edge of the base. One beneficial effect of this is that the formation of clinker is less likely to take place, owing to the uniformity of temperature at all points around the base of the fire. Studs cast upon the upper plate serve to loosen the fire when the grate is rotated. The second distinctive feature of the Fielding generator is the simple manner in which the supply of water, and therefore of steam, is automatically regulated instantly to suit varying loads.

It will be seen that the air is led to the central orifice in the rotatable base from a pipe at the side which connects it with a belt in the upper casting. This belt surrounds the hot gas chamber so that the air becomes very highly heated. At the lower end of the side pipe is the automatic water control, which is also shown to an enlarged scale in the illustration. From this it will be seen that an inverted water nozzle is placed above a pipe which allows the water dropping from the nozzle to escape, unless in it course downwards it is disturbed or deflected out of its normal path. Such deflection is caused by the rush of air past the nozzle when by the action of the engine piston, drawing its charge of gas from the generator, air is drawn into the generator. Under these circumstances the water is broken off into a spray and carried along with the hot air through the double rotatable grate, where, as already explained, it becomes superheated steam.

Thus it will be seen that whenever the engine draws a charge of gas, the necessary amount of steam is generated for that particular charge, and that whenever by the action of the governor the gas valve remains practically closed, the small amount of air drawn in not having sufficient velocity to carry the water with it, no steam is generated, except when the engine is taking a working charge. The gas valve always has a slight lift even when the governor cuts out a working charge, this having the effect of keeping the fire bright, but no water is drawn in a steam form.

It is claimed for the Fielding generator that it is capable of automatically adapting itself to varying loads. It will be observed that the automatic control involves the use of no working part, such as valves, pistons, flexible diaphragms, or other apparatus liable to derangement. It is said that the action of the water control is so sensitive that by watching the dropping of water from the escape pipe one may know when the engine governor cuts out a charge. The generator needs no explanation.

The scrubber is of the ordinary coke type, and differs from most of the others only in that it has dry coke placed above the water spray, through which the gases pass before being drawn through the expansion chamber to the engine.

Messrs. E. S. Hindley and Sons, of Bourton, Dorset, are entering a complete plant for the trials. This we illustrate in Fig. 12. The special feature of the plant is the engine, shown in Fig. 11, which has been designed for being coupled direct to high-speed machinery such as dynamos, centrifugal pumps, fans, &c. The makers claim to have embodied the following important features in the design of this engine. (i.) Great steadiness of running at all speeds. (ii.) A thoroughly automatic and continuous system of lubrication. (iii.) Careful proportion of parts, accurately balanced to eliminate vibration. (iv.) Free access to all parts. (v.) Silent working. (vi.) Minimum ground space. The steadiness of running is accounted for by three reasons: (*a*) That never less than two cylinders are used. (*b*) That the governor regulates the amount of gas used at every stroke in proportion to the load upon the engine, and does not cut off the whole supply of gas and allow an idle stroke. (*c*) That the cranks are so disposed that the impulses or explosions follow each other with exactly equal spaces between each. The engine is designed to develop 20 brake-horse-power at 600 revolutions when running on suction gas. The cylinders, which are water cooled, are made of close-grained cast iron 7in. diameter, and are in one with the valve box. The pistons have been made as light as possible, and have a stroke of 7in. They are each provided with seven rings, with two at the mouth end. The connecting-rods can be withdrawn along with the pistons through the top cover. The cover can be quickly removed without disconnecting any gear. The governor is of the balanced throttle type, varying the admission both of gas and air, and can be regulated so that the compression is practically constant, and ignition certain at all loads. All the revolving parts of the governor are enclosed. The governor springs act directly on the weights, thus relieving the fulcrums and joints of friction, rendering the governor sensitive in action. There is a regulating spring which allows the speed to be varied whilst the engine is running. Ignition is effected by means of a magneto machine, worked from the half-speed shaft of the engine through spur gearing.

The producer is shown in section in Fig. 13. The generator consists of the usual cast iron casing, lined with fire-brick of extra thickness, and further with dry sand to obviate any chance of the metal burning or corroding through the action of the fire. Two ash doors are provided opposite to each other for removing ashes from whichever way may be the most convenient. An internal non-pressure boiler is carried in the generator above the direct flame of the fire. The boiler is said to raise sufficient steam from the heat of the gases as they leave the fire, and not from the fire itself. The boiler is designed so that it can be readily cleaned. It can be exposed for examination by simply removing the top cover. There are no tubes, and apparently no narrow passages which could be choked by any deposit from the water. There is an internal passage for carrying the heated air and steam at a high temperature from the boiler to the under part of the grate. This passage is kept at a high temperature by the radiant heat from the fire. It is claimed that this duct acts in some measure as a superheater, ensuring hot, dry steam and air only to be delivered to the fire. This, it is said, maintains the fire at a temperature sufficiently high to disintegrate a large quantity of steam, thereby ensuring a gas rich in hydrogen and certain of ignition when it reaches the engine. The inner shell of the boiler acts as a hopper for holding a large quantity of coal, which feeds automatically, so that the plant can be left without attention for very long periods. Immediately after leaving the generator the gas passes through the inner of two concentric pipes, designed to separate all the heavier parts of cinder and coal that may be carried off from the fire. Here, also, it gives up a great part of its heat to the ingoing charge of air, which is made to pass up the outer of the two pipes. The air by this means is thoroughly heated, and is then immediately made to sweep right across the top of the boiler, where it takes up all steam as it is formed, and being heated first, none of the steam, it is claimed, is condensed by having to mix with cold air. The combined air and steam then pass down the internal passage already referred to, where they are again further heated before delivery to the fire. Thus no steam or mixture of air and steam is taken through external pipes.

The scrubber is of the ordinary coke type. Before passing through the coke the gas has to pass through a water seal, which is kept at a constant level by means of the overflow pipe. The outlet is fitted with the firm's two-level valve, so that the gas may be allowed to pass directly through the coke and not through a water seal, to facilitate starting. The plant can also be run without the seal, if desired, and the seal formed only when stopping. An expansion bore has been provided, from which the engine draws its supply of steam. This bore is fitted with test and drain cocks, &c.

The Mersey Engine Company, of Sefton-street, Liverpool, is exhibiting an interesting form of producer plant,

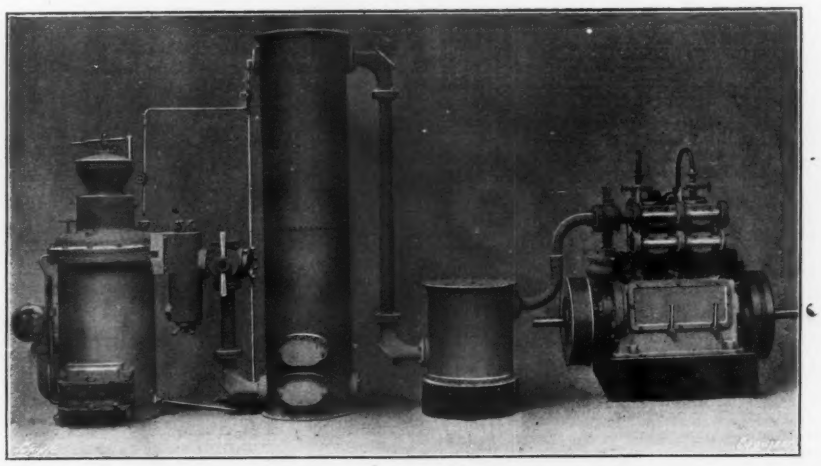


Fig. 12—HINDLEY AND SON'S COMPLETE POWER PLANT

which embodies several novel features. The generator is made of sheet steel, and is enclosed in an air jacket; the air before reaching the vaporiser passes through this jacket, and is consequently heated to a temperature which enables it to pick up the necessary steam in the vaporiser. Part of this steam is raised by means of the waste heat in the gas, after it leaves the producer, in the cast iron down pipe. Water is passed over the surface of this pipe by means of a saturated fibrous tape, the tape having, it is said, the advantage that it absorbs the

moisture and offers a big surface to the hot pipe. The remainder of the steam necessary is generated by means of the coil shown round the hopper tube at the top of the generator. A small quantity of water is supplied to this coil through the tap shown in the engraving Fig. 14, and the steam is delivered into the vaporiser. Any surplus water is carried down a pipe into the bottom of the generator, dripping on to the evaporation plate shown.

It is claimed that by the combination of these arrangements it is possible to get any quantity of steam required. The hopper is fitted with a circular valve so designed that fuel may be supplied without air entering the generator. It simply consists of a circular valve with a single opening. When the opening is at the top the fuel

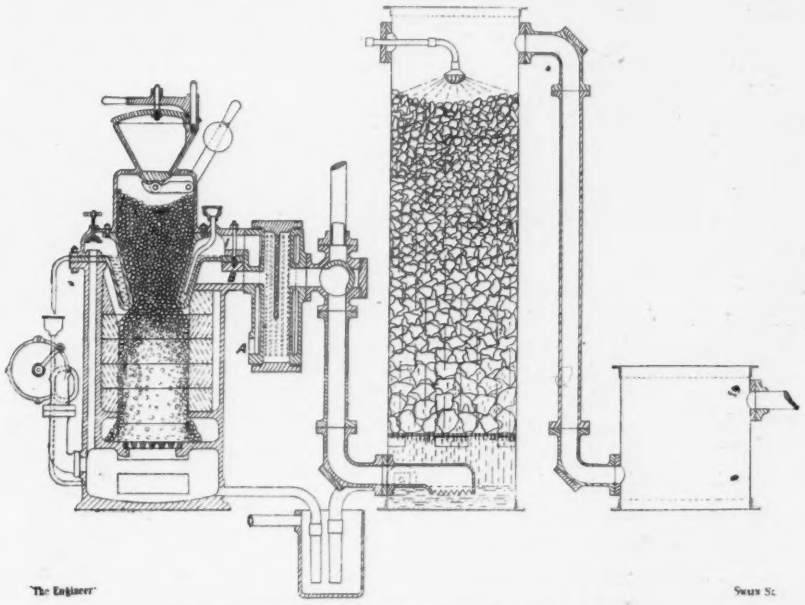


Fig. 13—SECTION OF HINDLEY'S SUCTION GAS PLANT

can be put into the valve, then by turning the valve half round, air is prevented from entering through the hopper, and the fuel drops into the generator. The starting fan is of special construction; it has a large capacity and is fitted with ball bearings. The air from this, as shown, passes into the annular chamber at the bottom of the generator. An elaborate system of cooling and cleaning the gases has been adopted. This consists of passing the gases through a washer, filter, and dryer. The washer takes the form of the usual coke scrubber. The nozzle of the water spray has been made readily removable for cleaning purposes, should dirty water be used. The filter is similar to the scrubber, and consists of a circular chamber containing coke, but in this instance there is no water spray. The dryer contains wood fibre, the fibre being contained between two perforated plates carried on a central rod, so that it may be removed quickly for cleaning, renewing, or other purposes. The method of starting is ingenious. The fire is blown for a few moments, then water is turned on the coil, this coil heating the water sufficiently to deliver it hot to the bottom of the generator. The water coming in contact with the hot plate at the bottom of the generator is immediately turned into steam. The chimney valve is then closed and engine started, after which the water is turned on the down pipe, which will be hot enough in a few moments to generate steam; the water on the coil being then adjusted to suit the load. Another point is that the doors may be opened at any time by simply turning the water on the coil, thus enabling the generator to be clinkered at full load, and, therefore, it is claimed, enabling it to be run continuously day and night for any period.

The trials of the different plants commenced at the Royal Agricultural Show at Derby on Monday morning at 9 o'clock. The twelve competing firms were: Campbell and Co., Limited; Crossley Brothers, Limited; the Dowson Economic Gas Company, Limited; the Dudbridge Ironworks; Davey, Paxman and Co., Limited; Fielding and Platt, Limited; Hindley and Sons; Kynoch and Co.; the Mersey Engine Company, Limited; the National Gas Engine Company, Limited; Newton Brothers; and the Railway and General Engineering Company, Limited. Two of the firms, Campbell and Co., Limited, of Halitax; and Crossley. Brothers, Limited, of Manchester, each entered two plants. Those submitted by the former company had precisely similar gas producers: the engines, however, were different, in that one was governed on the "hit-and-miss" principle, whereas the speed of the other was regulated by varying the supply of gas to the engines. In Messrs. Crossley's plants the engines were identical and the generators were different.

All the plant, one after the other, were started from cold on Monday morning. Several of them made poor starts, difficulties being experienced in getting the fires to "go." On the other hand, several plants started excellently, and when once started most of the plants ran well. Crossley's withdrew their new plant from the competition soon after starting, in view of the fact that the judge required the superheater to be worked throughout the trials, and this the firm did not feel inclined to do. After running for nine hours the plants were shut down, and running was resumed on Tuesday at nine o'clock. The times taken in starting, in the majority of cases,

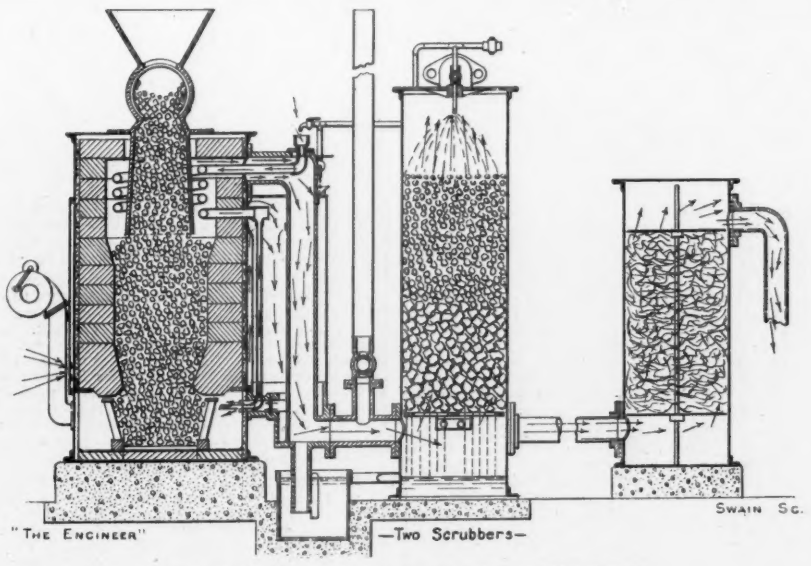


Fig. 14—SECTION OF THE MERSEY SUCTION GAS PLANT

were naturally much better than on the previous day. The run on the second day was for five hours under the same condition as before. Afterwards all the remaining coal was taken from the generators and weighed, and the amount of ash left, noted. The same conditions as on the previous day prevailed, and indicator diagrams were also again taken at intervals. On Wednesday the half-load trials were conducted on precisely the same lines as the full-load trials, but were of shorter duration. No-load tests and a run for nine hours with coke concluded the trials. A full report of them must, of course, be reserved until the judges have tabulated their observations.

OBITUARY.

THOMAS ROBERTSON.

THE death took place, from paralytic shock, on the 17th inst., of Mr. Thos. Robertson, C.V.O., of Cairleith, near Crieff. Mr. Robertson, who was in his sixty-seventh year, had a remarkably successful career in the railway service. Born at Bankfoot, Perthshire, he received his early training at the parish school there, and afterwards at the parish school of Madderty. Entering the service of the Highland Railway Company as a boy clerk, Mr. Robertson rapidly rose in the service until he attained the position of district superintendent of that railway. Many years ago he was appointed to the office of general manager of the Great Northern Railway of Ireland, and his management there resulted in the introduction of numerous important and beneficial changes. During his successful career as manager of this railway, Mr. Robertson's abilities were recognised by Mr. A. J. Balfour, then Chief Secretary for Ireland, and he offered him the position of Chairman of the Irish Board of Works, which was accepted. This office Mr. Robertson filled with much distinction and success for a good many years, when he retired from active business life. A few years after his retirement, however, he was requested by the then Prime Minister (the late Lord Salisbury) and the Secretary of State for India (Lord George Hamilton) to proceed to India and investigate the whole question of the working of the railways there, with a view to their re-organisation and the better development of the country. Mr. Robertson, with characteristic energy, at once accepted the important mission. He proceeded first to the United States of America and to Canada, where he travelled over most of the railway systems in these continents, and afterwards proceeded to India, where he also travelled extensively and made elaborate investigations during a period of over twelve months. From the time he left Britain till his return home he had travelled over 76,000 miles in connection with his work, and that, too, within the space of eighteen months. As a result of his mission of inquiry he presented an elaborate report to the Government, which recommended "root-and-branch" reform as being absolutely necessary if the development of the railways in India was not to be hampered, and if they were to be worked on thoroughly commercial lines, and render that full and efficient service to the country of which they are capable. The important recommendations in this report met with high approval from the commercial and official opinion of India. Mr. Robertson was unmarried, and is survived by Miss Robertson, his sister, who has long been his devoted companion.

G. J. SNELUS.

WE regret to have to record the death of Mr. George James Snelus, who died on Monday at his house, Ennerdale Hall, Frizington, Cumberland. Mr. Snelus was born on June 25th, 1837, in Camden Town, London. In 1864 he obtained a Royal Albert scholarship, and went to the Royal School of Mines at South Kensington, where he studied under Dr. Percy for three years. After this course of studies he was appointed chemist at the Dowlais Works, where he remained for four and a-half years. The Iron and Steel Institute selected Mr. Snelus to visit the United States and report upon the chemistry of the Danks rotary puddling furnace. It was during his visit that he discovered the fact that phosphorus could be removed from iron when the latter was in a molten state. Having proved that lime burned at a high temperature was impervious to water, it occurred to him that if he used lime so overburnt for lining the Bessemer converter, he would get a basic lining which would not be acted upon by a basic slag, and so would be able to eliminate the phosphorus during the Bessemer process. This surmise proved to be correct. The Iron and Steel Institute awarded Mr. Snelus, jointly with Sidney Thomas, their Bessemer medal in 1883 for the part he had played in the development of that process. He was awarded gold medals at the Paris Exhibition of 1878 and the Inventions Exhibition, 1885, and also a silver medal at the Paris Exhibition of 1900. He was the author of many scientific papers dealing with metallurgy, and his attainments were recognised by the Royal Society, of which he became a Fellow in 1887. Mr. Snelus was a vice-president of the Iron and Steel Institute, and had been a member since its foundation. He was also a member of the Institution of Mechanical Engineers.

JOHN GRIFFITH.

STILL another of the old school of colliery managers and mining engineers has disappeared from the Welsh colliery districts in the person of Mr. John Griffith. In the year 1850 he worked at Lletty Shenkin Colliery, Cwmbach, then owned by Mr. Rees, brother of Lady Lewis, and eventually came prominently under the notice of Sir W. T. Lewis. On the death of the manager, Mr. John Williams, he was appointed manager, and remained in efficient control of this important colliery until it passed into the ownership of Burnyeat Brown and Co. in 1872. He was then offered the vacancy of manager at the Foxholes Collieries, Swansea Valley, which was long retained. Eventually Mr. Griffith returned to the Aberdare Valley, and was connected with collieries in that district and in the Rhondda Valley. One of his last positions was in association with the late Mr. Herbert Kirkhouse at Tylerstown. He died on June 15th in his seventy-fourth year. One can now almost reckon on the fingers of one hand the remaining survivors of the old band of colliery managers, who, starting when the simple adit, or level, was the mode of winning coal, worked through an arduous course of colliery development, culminating in such ordinary outputs as one and two thousand tons per diem. Getting their mining knowledge by hard practical experience, they held to it tenaciously, and were not ready in accepting the direction of the modern engineer; but such a man as Mr. John Griffith was always held in respect, and his judgment especially received with consideration. Mr. Griffith lived through the great series of colliery disasters, from which Lletty Shenkin and Tylerstown were not exempt.

RAILWAY MATTERS.

THE London and North-Western Railway will open its new station at Crewe for passenger traffic on Sunday next.

A STEADY demand for railway materials in Peru is likely to exist for years to come, inasmuch as the Government propose to construct lines in several directions.

WE are requested to state that the Railway Club will pay a visit to Bagworth Colliery and Thornton Reservoir on Saturday next, leaving Leicester, Midland Station, at 2.50 p.m.

THE Diamond Jubilee of the London and North-Western Railway Company will take place on the 16th July next. The Act for the formation of the company received the Royal Assent on the 16th July, 1846.

BY arrangement between the Great Western Railway Company and the Thames Conservancy, the bridges carrying the railway over the Thames are in future to be painted in two shades of green, in order to harmonise with the landscape.

THE London and North-Western Railway Company contemplates constructing an embankment about six miles long, to protect the line on the North Wales coast, east of Abergele and Rhyl. The sea has of late years made serious inroads. It is also proposed to raise the level of the line where possible.

THE Great Eastern Railway, on the 30th inst., will commence a new arrangement, under which cheap week-end tickets will be issued every Saturday by any train from London to all stations in the Eastern Counties beyond about 50 miles from the metropolis, and the tickets will be available for return on either the Sunday or Monday.

AT a special meeting of the Buenos Ayres and Pacific Railway last week, sanction was given to the increase of the ordinary capital to two millions sterling in 200,000 of £10 each. This will have the effect of raising the authorised ordinary stock from four to six millions, but only half of the newly created capital is to be raised at present.

THE famous old locomotive Invicta has been presented to Canterbury by Sir David Salomons, and it has been erected on the Dane John. The Invicta was the first locomotive of the Canterbury and Whitstable Railway, opened on 3rd May, 1830. Sir D. Salomons recently offered the Invicta to the London County Council, to be set up by the southern approach to Westminster Bridge, and also £1000 for the pedestal, but the offer was not accepted.

THE North-Eastern Railway Company proposes shortly to develop the service of auto-cars which have been so successful between the two Hartlepools and between Newcastle and Ponteland, by running auto-cars on the Blyth to Tynemouth branch and raising the number of trains from six to seventeen per day. This is the answer to recent attempts to get the Tynemouth tramway service extended to Blyth, and to establish a service of motor cars between the two places.

ALTERNATIVE tenders will be received at the office of the High Commissioner for New Zealand, Westminster Chambers, 13, Victoria-street, London, S.W., for the construction of a tunnel 5 miles 24½ chains in length, at Arthur's Pass, through the dividing range between Canterbury and Westland, on the route of the New Zealand Midland Railway. Tenders, marked on the outside "Tender for Arthur's Pass Tunnel, '60 Months' or '48 Months,'" will be received up till noon on Monday, 9th July, 1906.

SINCE the disaster at Charing Cross last year the Continental boat trains have all been despatched from Victoria, but progress with the work of reconstructing the damaged parts of the station is now sufficiently advanced to enable the South-Eastern and Chatham Railway authorities to resume this traffic on the 1st proximo. An important change is to be made in the Ostend service, which will be transferred from Victoria to Charing Cross, and will reduce the time of the journey to and from Ostend.

IN reply to Mr. Shackleton, the Under Secretary for the Colonies in the House of Commons last week said that, as a consequence of the speech delivered by the Prime Minister to the deputation from the British Cotton Growing Association on 17th May, he deems it his duty to prepare a definite scheme of Nigerian railway extension for submission to the Cabinet. This scheme will be prepared in consultation with the Governor of Southern Nigeria and the High Commissioner of Northern Nigeria, who will both soon be in England.

CONTRACTS have been let for the construction of the Newburgh and North of Fife Railway, by which one of the most attractive parts of Fife will be opened up. The railway commences by a junction with the North British main line at Clenburnie, and passes along the valley through the village of Lindores, within a short distance of the foot of Norman's Law, thence past Luthrie, Rathillet, through the picturesque village of Kilmany. It then follows the line of the Motray Water, and joins the North British main line to Aberdeen at St. Fort Station. The line, which is 12 miles long, is being constructed by a separate company, and is to be worked by the North British Railway Company under agreement.

THE Board of Trade have appointed a committee, consisting of Mr. A. Clayton Cole, chairman; Mr. W. M. Acworth, Mr. W. Bailey, chief accountant of the Midland Railway; Mr. G. Stapylton Barnes, Board of Trade; Mr. A. Wilson Fox, C.B., Board of Trade; Sir Charles J. Owens, general manager of the London and South-Western Railway; Mr. G. Paish, Hon. George Peel, and Mr. G. J. Whitelaw, chief accountant of the Great Western Railway; with Mr. H. Fountain, Board of Trade as their secretary, to consider and report what changes, if any, are desirable in the form and scope of the accounts and statistical returns—capital, traffic, receipts, and expenditure—rendered by railway companies under the Railway Regulation Acts.

THE forty-eighth annual meeting of the members of the Railway Benevolent Institution was held on Monday, Sir George Gibb presiding. The Board of Management stated in their report that the revenue from all sources exceeded that of 1905 by £7362. The donations were less by £2815; the subscriptions showed an increase of £1074, and the special appeal yielded more by £1053. There are now in receipt of permanent annuities 254 officers and servants and 829 widows, while 368 children are being educated at Derby and elsewhere. There are 104 members and 493 widows awaiting their turn for admission as vacancies arise. There are 597 candidates for permanent annuities amounting to £11,039, as against 539 for £9954 in 1905. The number of members of the casualty fund stands at 134,595, and out of the special benevolent fund grants have been made amounting to £3628.

ONE of the most destructive fires which has occurred in Glasgow for some considerable time took place in the early hours of the morning of the 16th inst., in the St. Rollox Works of the Caledonian Railway Company. The works consisted of carriage and wagon building, and repairing shops, where passenger carriages and goods wagons of all descriptions are turned out complete, having an area of no less than 14 acres covered in by glass roofing. The fire originated in the boiler-house or engine-room of the saw mill, and spread with amazing rapidity; and there succumbed to the devastating element the carriage and wagon building and repairing shops, the cabinet makers' workshop, and the carriage and wagon building store, together, of course, with the rolling stock machinery, &c., which they contained. The flames were prevented from spreading to the turning shop, which building remains intact. Estimates of the damage vary from £35,000 to £80,000.

NOTES AND MEMORANDA.

AN alloy which will withstand the action of water under pressure in a metal valve, and which is used by one of the largest firms in the country, consists of the following ingredients:—Copper, 10; tin, 1; zinc, 7/16; lead, ½.

A REUTER telegram from Ottawa of Monday's date, says the Canadian Pacific steamer Empress of Britain, has covered the distance between Moville, Ireland, and Rimouski, Quebec, in 5 days 21 hours 17 minutes. This time is 63 minutes better than any former passage on record.

SOME German cannons, fitted with the new tubular recoil apparatus, have been put at the disposal of several army corps. The rifle provided with a similar arrangement, which is said to have proved very efficient, has already been served out to several infantry divisions, and is to be adopted generally so soon as funds permit.

RECENT experiments are said to have demonstrated that cadmium gives protective coatings for iron much superior to zinc. The coat has the same aspect as zinc, but is much more adhesive, and harder. Like zinc, it finally becomes tarnished, but less rapidly. It withstands the effects of acid fumes better than zinc.

A ROME telegram to the Paris *Eclair* states that Signor Battelli, Professor of Physics at the University of Pisa, has discovered a substance of the same nature as radium, but possesses much more powerful properties. The discovery, says Reuter, is believed to be of great importance from an industrial as well as a scientific point of view.

A FRENCH Society has commenced the manufacture of a new product called hydrolithe—calcium hydride. It is obtained by the reaction of metallic calcium, manufactured by electrolysis in this same works, on a metallic salt. This hydride of calcium gives, under the action of water, pure hydrogen, just as calcium carbide gives acetylene. The industrial product gives 1000 litres per kilogramme.

ACCORDING to an improved process, a new use may possibly be created for zinc sheets. Tests which have been carried out with compressed seamless zinc tubes are said to have proved that, in point of strength and elasticity, they are approximately equal to copper and brass tubes. Owing to their not being chemically affected by naphtha or petroleum, these compressed seamless zinc tubes may be found useful in the petroleum-refining industry.

THE hydro-electric plant of the Pike's Peak Hydro-Electric Company enjoys, it is said, the distinction of operating with the highest head of water yet attempted. The present plant utilises about 2200ft. of effective head, after all deductions for friction of pipes, producing a pressure of close upon 1000 lb. per square inch. It further occupies an exceptional position among water-power plants, in that its water wheels are operated with water belonging to a city waterworks.

THE German *Post* complains that English constructors have taken the place that the Germans had won by the assistance rendered to Russia during the war with Japan, and fears that the orders of the Russian Navy will go to British shipyards after having "saturated" French constructors. The *Post* also advises German manufacturers to prepare themselves to combat British competition, and also to appeal to German finance and diplomacy, so as to neglect no factor that may aid them in sustaining the strife.

THE new Austro-Hungarian field piece is reported to the *Mémorial Diplomatique* to be the best now existing in Europe, being of forged gun-metal. The bore is 7·65 cm.—3in. full—and the length 30 calibres. It is fitted with a telescopic sighting arrangement, and protected by a nickel-steel shield 4 mm. thick, while the length of the recoil tube is 1·17 m. = 3ft. 10in. The total weight with carriage is 1·76 metrical ton. The initial velocity of projectile is 530 m. = equal 1738ft., per second, and the maximum range 6300 m. = 6889 yards.

A LARGE chimney of reinforced concrete—the first of this form of construction in the United Kingdom—is to be erected by the Weber Steel-Concrete Chimney Company at Northfleet. Its total height from base of foundation to top will be 247ft., the diameter of flue 8ft. 6in., and the foundation 18ft. square. The weight of the chimney, including the base, is 868 tons. A similar chimney is now being built at a sugar refinery at Plaistow Wharf, Victoria Dock, which has a total height of 261ft., a diameter of flue of 20ft., and a base of foundation of 25ft. square.

THE world's record in gunnery has been established on the U.S. battleship Ohio by D. M. Dean, whose score was thirteen bullseyes out of thirteen shots in one minute, with a 6in. gun. We learn from an American paper that the Ohio was steaming at 10 knots at the time, and the target was distant 1600 yards. The best previous record for this size gun was eleven hits out of fourteen shots, made by one of the gun pointers of the British Navy. When it is realised that as recently as the Spanish war the 6in. guns, as fitted on the Oregon, were capable of only about two shots per minute, the importance of this record and the immense forward strides which it indicates become all the more apparent.

THE "Annual Report on Admiralty Surveys" for last year has been issued as a parliamentary paper. The Hydrographer's report states that in the course of 1905 eleven vessels were employed in the work of survey in different parts of the globe. During the year rocks and shoals to the number of 522 were discovered. Surveying vessels reported 145 of these, others of H.M.'s ships accounted for eleven, eighteen were announced by various British and foreign vessels, twenty-six were discovered by ships striking on them, and the remaining 322 were reported by colonial and foreign Governments. Coastline to the extent of 1129 miles has been charted, and soundings have been made over an area of 4295 square miles.

THE Committee appointed by the French Chamber to inquire into the working of the Eight Hour Act has sent in its report, from which it appears that the number of industrial establishments where the eight-hour day is possible is so small that it was necessary, for arriving at anything like a just conclusion, also to take into account reductions of the working day for nine and even for ten hours. The inquiry bore upon 396 establishments in eighty-three different branches of industry, which had during the last few years reduced the day in different proportions; and it was found that a reduction of more than one hour greatly increased the cost of labour. In the forty-eight establishments where the eight-hour day had been adopted the cost of production had increased from 4 per cent. to 20 per cent.

A SUBMERGENCE test of a new American submarine, the Lake, was held at Newport News lately, and the sinking contrivances were found to work without a hitch. The Lake cruised up and down stream several times, says the *Army and Navy Journal*, then the submergence tanks were flooded and the craft slid beneath the waves, only the tip of the omniscope remaining in view. After rising and sinking tests, lasting almost an hour, the boat was returned to dock. The boat is 85ft. in length, and has a diving chamber in the bow from which a diver may emerge. This chamber is fitted with grappling contrivances for use in picking up cables. There are three torpedo tubes and space for carrying at least two extra torpedoes. The tanks for gasoline are all situated outside of the capsule, and their capacity is sufficient for a run of 1000 miles,

MISCELLANEA.

A CONCERT will be given on July 11th, at the Queen's Hall, Langham-place, in aid of the building fund of the Union Jack Club.

THE U.S. House of Representatives have adopted by 129 votes to 82 the resolution of the Senate providing that material and equipment used in the construction of the Panama Canal shall be purchased from home manufacturers unless the President deems their prices extortionate.

QUEENSLAND possesses about 40,000,000 acres, or some 62,500 square miles of forests producing merchantable timbers, lying between the eastern seaboard and the Great Dividing Range, which traverses the country from north to south at a nearly uniform distance of 200 miles from the coast.

THE Acting British Consul at Amsterdam reports that the municipal authorities of the city of Groningen invite plans, with statement of prices and time, for the construction, on the grounds of the municipal gas factory, of a gasholder—including foundation—of a diameter of about 42 metres and a capacity of about 30,000 cubic metres. General drawings and conditions may be obtained from the "Directeur van het Gasbedrijf," Groningen, on payment of 2·50 florins.

IN Great Britain, generally speaking, any man who is a potential buyer of machine tools is quite confident that he knows far more of their designs and construction than the tool maker does, says the *American Machinist*. The result of all this has been a tremendous waste of money and energy. The pattern stores of an English tool maker would astonish some American machine builders, and the shop organisation brought about by these conditions is naturally chaotic.

THE New South Wales Government has decided upon an extensive irrigation scheme. It has been decided to construct a large dam on the Murrumbidgee River at a place called Barren Jack. From here water will be carried in irrigation canals over an area of 358,000 acres. The work will cost about £1,500,000. The dam is to be built three miles below the confluence of the Murrumbidgee and Goodradigbee rivers, and when completed will be 200ft. in height and 900ft. in length.

THOUGH it is not yet possible to say how long it will be before the water found at the Boultham boring, Lincoln, is available for domestic consumption, the supply is likely to exceed the most sanguine anticipations. The consulting engineer has expressed entire satisfaction at the prospect, and it is probable from the evidence furnished by the flow of water up to the present that two million gallons per day may be forthcoming, which would be adequate for the requirements of the city.

A SCHEME has been propounded to take a supply of water for Birkenhead from the river Alwen. The scheme is divided into three sections. The first involves an outlay of £750,000, and will provide eight million gallons of water daily. The second will cost £545,000, and yield nearly six million gallons of water daily, and the third will cost £464,000 and yield from four to five million gallons daily. The Alwen joins the Dee near Corwen, and is about twenty miles long. The water will be carried a distance of forty-two miles.

THE proposal to establish a sugar-beet factory in Lincolnshire is said to be making headway, but the suitability of the soil to raise large crops has yet to be ascertained. Free seed has been given to a number of farmers, who are this year devoting part of their land to the sugar beet, and if successful crops result, a sugar factory will be erected. The present experiment is, as the *Times* remarks, therefore, extremely important, as on its success will depend the actual beginning of the British sugar-beet industry.

DURING the present week the Deputy Master and a Committee of Elder Brethren, accompanied by Lord Rayleigh and the Corporation's engineer-in-chief, have been carrying out a series of experiments at St. Catherine's Lighthouse, Isle of Wight, with the diaphone fog signal, which has been brought to the notice of the Trinity House by the Canadian Fog Signal Company, of Toronto, Canada. Very excellent results are stated to have been obtained with this instrument in Canada, and considerable interest has been taken in the matter by various public authorities.

GALVESTON, last year, ranked second in the United States as an exporting point, New York alone surpassing it, with New Orleans third. As a cotton-exporting port Galveston was easily first. The exports to foreign countries from Galveston in 1905 were valued at £29,995,163, as compared with £25,224,703 in 1904. Mr. Consul Nugent, in his report on the trade of Texas for 1905, states that if Galveston be the natural outlet for the immense cotton crop of Texas, it is no less the natural port for the shipment of a great proportion of the breadstuffs exported to Europe.

IT is hoped, now that the South Staffordshire Mines Drainage Commissioners are getting their new drainage scheme well under way, that a larger area of mines will be opened up. A correspondent of the *Times* says that about £68,000 is being spent in works for underground drainage, and some £20,000 on appliances to deal with storm and other surface water. The new plant comprises some powerful engines and pumps, and steam, Mond gas, electricity, and wind power are all being called into requisition to provide motive power. The provision and working of the plant will cost £11,630 a year—a large increase upon the previous cost.

ONE of the great difficulties in mining on the Bolivian tableland is the want of cheap motive power. Permanent water power is not generally available to any extent. Coal is too expensive, and the native fuels are getting scarce. A solution appears to have been found to some extent in the employment of gas engines and producers. Makers of this class of gas plant should give attention to the effect of altitude on the efficiency of gas engines for countries such as this district, namely, from 12,000ft. to 14,000ft. The gas engines in use give about a 70 per cent. efficiency, using about 1·5 lb. of anthracite per horse-power hour. These are the figures for plants near the Antofagasta Railway.

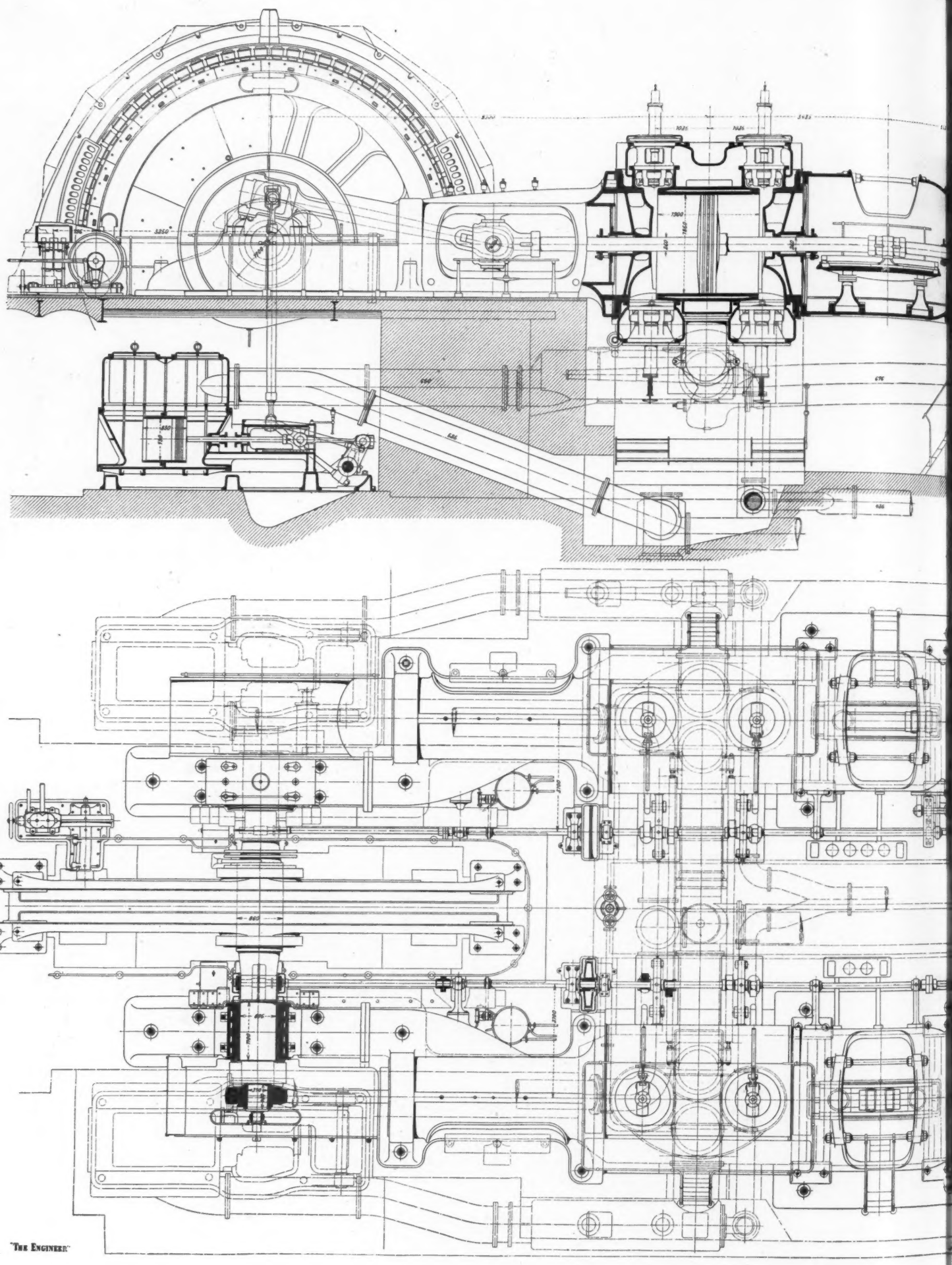
THE import of coal into Roumania is greatly falling off, owing to the constant and rapid increase of the employment on the railways of a mixture of lignite and petroleum refuse. This is now almost invariably used to the exclusion of foreign coal. The use of this fuel in manufactories, combined with the equally rapid increase of the use of petroleum as a motive power, practically makes Roumania dispense with the use of British coal, except for steam navigation and the manufacture of gas, and although there has been a considerable progressive increase in the importation of British coal since 1900, the figures fall largely below the imports during the last decade of the last century, when they frequently amounted to over 250,000 tons.

INTENDING visitors to the Milan Exhibition journeying from London and by the Gothard line may save 3 hours 20 minutes of the most fatiguing part of the whole journey out by going *vid* Folkestone and Boulogne, instead of by Calais. From Boulogne the route is *vid* Amiens, and by Calais it is through Lille and the "Black Country" of North France. The three hours twenty minutes later start from London by the fast Boulogne-Folkestone route is made up at Laon—terminus of the French Eastern Railways—where the two trains form one. The explanation is the very slow travelling on the "Nord" Calais to Laon section. In the return journey, London is reached 1 hour 22 minutes earlier *vid* Boulogne and Folkestone. The saving in fatigue, as well as time, is most appreciable

6000-H.P. ENGINE AND GENERATOR AT TH OE

GOERLITZER MASCHINENBAU STALT, G

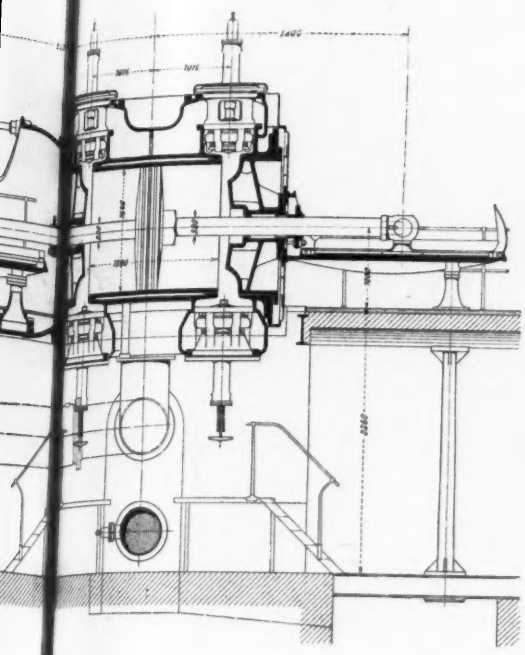
(For descripti page 624.)

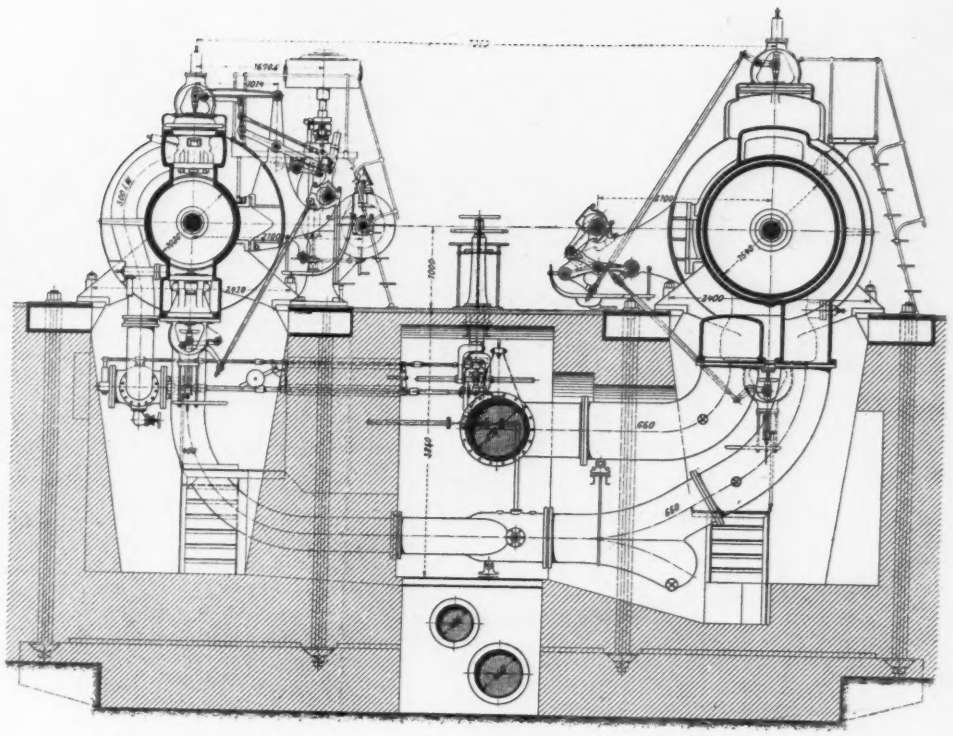


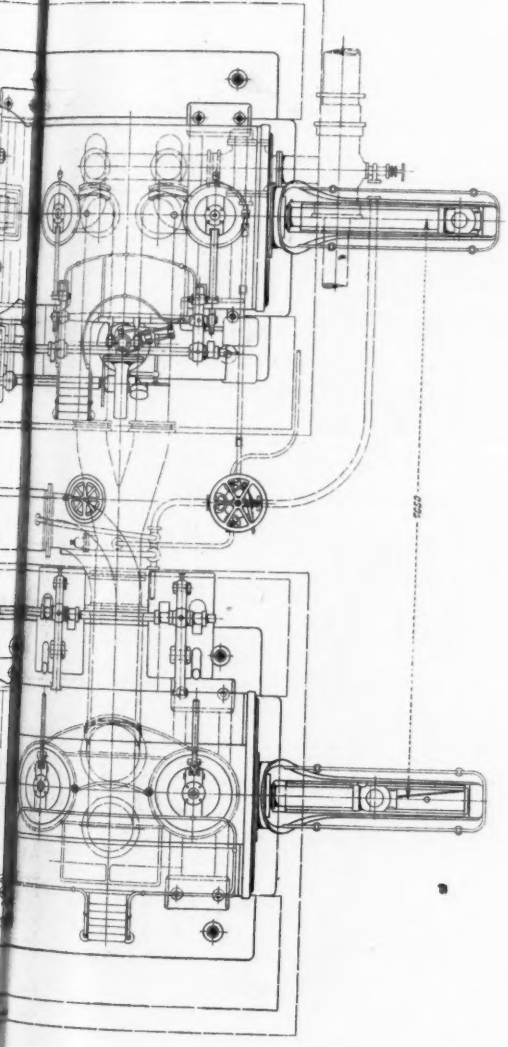
TH OBERSPREE CENTRAL STATION, BERLIN

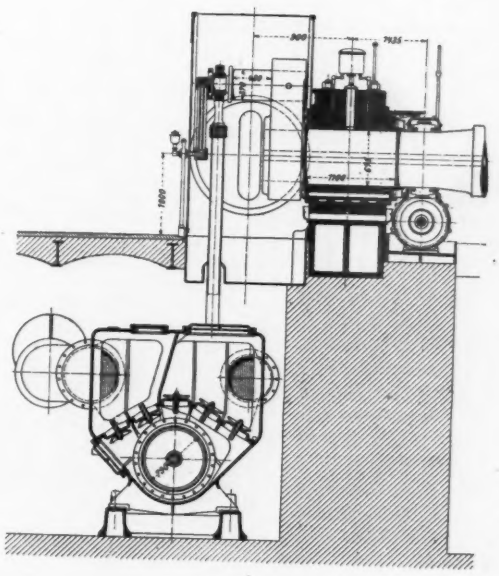
INENBAU STALT, GOERLITZ, ENGINEERS

(For description see page 624)









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Advertisements cannot be inserted unless delivered before Six o'clock on Thursday evening, and, in consequence of the necessity for going to press early with a portion of the edition, ALTERATIONS to standing advertisements should arrive not later than Ten o'clock on Tuesday morning in each week.

Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

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PUBLISHER'S NOTICES.

*** *With this week's number is issued, as a Supplement, a Two-page Drawing of a 6000 H.P. Engine and Generator at the Oberspree Central Station, Berlin. Every copy as issued by the Publisher includes a copy of this Supplement, and subscribers are requested to notify the fact should they not receive it.*

*** *If any subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

J. E. M.—See Seaton's "Manual of Marine Engineering," published by Griffin.

R. D. (Beverley).—You could possibly get some old papers by application to the Secretary, or more probably from some one who has sat for the examinations. You will find some papers reprinted as an appendix to Professor Jamieson's books (see "Applied Mechanics," vol. ii.).

MANAGER.—Books on works management are not of great value. You might see Barber's "Management of Small Engineering Works," published by the Technical Publishing Company, Manchester, price 7s. 6d. On commercial organisation you cannot do better than study the series now running in these columns.

ENGINEER.—(1) The theoretical consumption under the conditions you give, allowing nothing for condensation and other losses, would be ·37 cubic feet per minute. (2) Not sufficiently explicit. Do you want to know how to carry out tests, or to have an account of the best results obtained? See John Perry's "The Steam Engine."

DEATH.

On the 17th inst., at Cairnleith, Crieff, THOMAS ROBERTSON, C.V.O., late General Manager of the Great Northern Railway, Ireland, afterwards Chairman of the Irish Board of Works, and latterly Special Commissioner on Indian Railways.

THE ENGINEER.

JUNE 22, 1906.

Charing Cross Station Roof.

THE report of Major Pringle, R.E., to the Assistant Secretary to the Board of Trade on the fall of a portion of the roof of the Charing Cross terminus of the South-Eastern and Chatham Railway has just been issued. As we give the essential portions of the report with diagrams on another page, it would be but waste of space to re-state the facts here. The report is remarkable in that it contains a detailed expression of opinion by two eminent engineers—Sir John Wolfe Barry and Sir Benjamin Baker—on a failure which is, in its main features and circumstances, without a precedent. What these gentlemen had to say on the subject is the more interesting in that it embodies if not an absolutely novel view of how such a catastrophe might be brought about, still a theory which will not, we feel sure, be accepted universally without hesitation. In dealing with this theory, we shall not go far wrong if we keep steadily in mind that we are dealing with deductions, not certainties, drawn from facts.

Now, if we read the evidence with care it will be seen that really the matter calling for explanation is not why the tie bar broke, but why it had not broken for a period of forty-four years. The explanation of this as given by Major Pringle is, we do not hesitate to say, quite inconclusive. On examination one end of the bar which had been by chance protected from the weather by some galvanised iron roofing sheets it was found to have had originally a large flaw, the result of imperfect welding. This is moderately well shown in the photograph on page 636, reproduced from our issue of Jan. 12th. The resisting power of the bar depended, we are told, on a sound area of about one-third of the total section of the bar. This sound portion, furthermore, was not coincident with the centre of gravity of the cross section, which means that a certain bending effort was exerted by the stress. According to Major Pringle this was neutralised and the stress equalised in the following way:—"The total area of metal which was doing work in resisting tension at the moment when the bar broke may be roughly estimated at about one third of the whole area, or from five to six square inches. The total calculated stress in tension was 81·5 tons, or from 13 to 16 tons per square inch of available metal. Taking into consideration the excentric position of the bulk of the available area A, it will be admitted that so high a stress would be certain to cause rupture the moment the thread-like points of contact in the area C parted."

It is admitted that the iron of which the tie bar was made had lost nothing of its original test-house strength. It was good for 20 tons per square inch. It follows therefore that even a stress of 16 tons per square inch should not have broken the bar unless cross-bending stresses had been set up by the one-sided position of the fracture, as stated above. Of the amount of this cross-bending stress no evidence is available. Major Pringle neutralises the validity of his theory by calling the points of contact in the area C "thread like." Really we do not see how threads could have done anything whatever to support the roof. Their area was so small, that even if they did not break they ought to have stretched under a force much less than that needed to keep the line of stress in the centre of gravity of the bar. The idea that these "threads" gave way first is based on pure theory. No one knows, or ever can know, where failure began. We cannot accept the assumption that the whole safety of the roof hung on two or three threads, nor do we think that Major Pringle really intended that we should.

Let us turn now to Sir Benjamin Baker's explanation. He holds, very rightly, that a flaw existed from the beginning, and that this flaw gradually extended in the course of forty-four years, until at last the area of sound iron remaining was too weak to bear the stress. This explanation deserves very careful examination. If it is true, important deductions follow of necessity. It may be said, in the first place, that hitherto it has never been taken for granted that an initial flaw will extend under a static stress well within the elastic limit. It may be answered that, in the case of the Charing Cross roof, the stress was not purely static, and there is, therefore, force in the contention that dynamic conditions did, to some extent, exist under which the flaw might have extended; but Sir Benjamin does not take dynamic stresses into consideration at all. We have next to consider what is the evidence in favour of an extension of the flaw really having taken place. The weld was a jump weld, the angle of the scarf being very steep; union was effected mainly by hitting the screwed portion of the bar on the end. There was very little side or circumferential swaging required. Jump welds are naturally treacherous. In this case a pellicle of cinder was shut up between the two surfaces. How thick it was does not appear in the report, probably it was not thicker than a sheet of paper. According to Sir Benjamin Baker, the periphery of the cavity containing this flake of cinder constituted an approximately circular "crack," which crack extended by degrees. Whether this solution of continuity was really a crack or not is a matter about which opinions will differ. Sir Benjamin Baker, in his explanation of what occurred, holds that it was absolutely clear that the flaw must have increased from the time the roof was put up. He says: "Now as to the reason why a flaw increases. Theoretically, if you get an initial crack, the stress is infinite at the bottom of it. If the material were perfectly elastic in a scientific sense, there is an infinite strain in the molecules at the bottom of the crack. The material is not, luckily, perfect, and so there is not an infinite stress, but a very heavy stress, which causes tearing. There is a higher stress at the bottom of the crack than at any other part, and the result is that it goes gradually, atom by atom."

We now come to the crux of the whole question. All the witnesses are agreed that the circumference of the weld was hermetically sealed. The report is perfectly definite and precise on this point. How, then, is the discoloration of a large area round the central pellicle of cinder to be explained? If moist air could not gain access, a mere extension of the crack over no matter how long a period would leave the opened surfaces as bright and crystalline as they were at first. It seems to be clear that the bar was originally unsound over a considerable area. If we turn to Mr. Kirkaldy's evidence we see that in effect this is what he said. It is not that cinder interposed; on the contrary, the surfaces had been in contact, but the metal was not equal in quality over the area shaded with horizontal lines in the diagram and marked C to that of the rest of the bar. We, of course, cannot go outside the four corners of the printed report, but we think that it contains enough to justify the construction of another hypothesis, which is simply that the iron was overheated and "burned," with the direct result that it would be discoloured by partial oxidation, and, to use a smith's shop phrase, would "lose its nature" to some extent. The gradual extension of the flaw in this case would be unnecessary. The dark area and poor iron existed from the first. The union possessed some strength, how much cannot now be said; but iron injured by overheating may resist as much as five or six tons, or even more, per square inch in the testing machine. It will be seen that this hypothesis accounts for the discoloration, and is not inconsistent with any assumption save that the bar could not have sustained a proof stress of nine tons per inch. There is, however, absolutely no direct evidence that this bar had ever been tested at all. It is true that Mr. Phillips, who had put up a similar roof at New-street in Birmingham two years before, had tested the bars for it; but, notwithstanding that fact, his note-books contain no record of any

hydraulic test of the Charing Cross bars. The facts cannot be got at now, it seems; but it must be kept in mind that the theory that the bars were hydraulically tested to nine tons on the square inch rests on no surer foundation than the fact that the New-street Station bars had been so tested. Yet, even if the test had been applied, it is quite possible that the weld might have stood, seeing that the stress was less than half the strength of the sound metal. Sir Benjamin appears to have argued in this way. The sound section of the bar was too small in area to carry the load; or, at all events, it could not have withstood the proof stress. But the roof has stood for forty-four years, and endured the proof stress; therefore the flaw must have been much smaller at first than it was when the bar gave way. It could only have grown larger from the inside out. This reasoning is very complete, logical, and cogent up to a certain point. But it leaves the discoloration wholly unexplained, and it can—as we believe we have shown—be upset at once if we suppose that the badly welded portion C had some strength; indeed, it is only necessary to extend Major Pringle's view a little to prove that there was nothing incompatible between the standing of the roof and the small area of intact metal. Its final destruction was, we venture to think, due to constantly repeated dynamic stresses, and probably cross bending, which took place as the roof rose and fell under the influence of wind pressure, changes of temperature, and the variations in the distribution of the load due to the weight of the repairing stages. The bars, it will be remembered, were rigidly united by the muff couplings, and that not in a right line but at an angle. Gradual deterioration might very well go on throughout the "burned" iron, although the sound metal remained as good as at first.

It is worth notice that although the bar is supposed to have been broken by tension, no extension whatever took place such as would have occurred in the test house. Wrought iron thus behaved precisely as steel is known to do. In great degree the interest which belongs to the questions raised may be regarded as academic, because no such roof will ever be erected in the future. The Charing Cross roof was by no means the only one of the kind. It has formed no part of our purpose to assert that Sir Benjamin Baker has taken an erroneous view, but simply to point out that his explanation leaves the discoloration of the section unexplained. If he is right, then alarm may well be felt concerning not a few old structures on which reliance is still being placed. That the consequences of flaw may be felt, and that disastrously, nearly half a century after a structure was made, is not a very pleasant truth to learn for the first time.

Irish Light Railways.

THE light railways of County Donegal are on a gauge of 3ft., and are controlled by two companies, the Donegal Railway Company owning and working the southern line, and the Londonderry and Lough Swilly Railway Company the northern. The southern line runs from Londonderry *viâ* Strabane to Stranorlar, where it branches off westwards to Glenties, and south-westwards *viâ* Donegal to Killybegs. From Donegal a branch goes south to Ballyshannon, and the portions from Stranorlar to Glenties, and Donegal to Killybegs, were constructed by Government, and are known as "Balfour Railways." The northern line runs from Londonderry to Buncrana and Carndonagh, and at Tooban Junction branches off *viâ* Letterkenny to Burtonport. The approximate mileage of the two systems is 105 miles and 99 miles respectively, or a total of 204 miles. A connecting line between the two systems is now under construction from Strabane to Letterkenny, about 15 miles in length, but for some (unascertained) reason is being run into an independent station alongside the existing one at Letterkenny. The Midland Railway of England, which recently took over the control of the Belfast and Northern Counties Railway 6ft. gauge lines, is about to acquire control of the Donegal Railway, and, doubtless, will at some future period extend its control to include also the Lough Swilly lines.

The term "light railway" as used for these narrow-gauge lines seems to be a misnomer, as there is nothing light about them except in so far as the weight of rails and stock is proportional to the gauge as compared with the broad or 6ft. gauge. They are as completely constructed and equipped as the heavier lines, and are fully interlocked and signalled, and worked by electric tablet or staff throughout. The engines are extremely powerful for their gauge, and the carriage and wagon stock well built, roomy, and comfortable. But the maintenance is poor, the rolling stock exhibiting a sad want of paint and cleaning, and the engines showing many leaky steam joints. The "road" is not yet old enough to show much sign of decay, but the condition of the ironwork of the bridges, especially underbridges, which seem to be rarely inspected from below, points to great neglect and want of funds. This want of money for proper maintenance is apparently due to the impossibility of earning a fair return on the capital expended. This seems to be due to two causes, first, excessive expenditure on original construction, and secondly, excessive expenditure in working the traffic. As to the first cause, the lines, especially the "Balfour" sections, are extravagantly equipped for the work they have to do. They run through long tracts of moorland where but few men or cattle are ever seen. Yet they are fully fenced and provided with level-crossing gates duly signalled, expensive interlocked stations, and electric tablet apparatus suitable for a heavy single-line traffic in the heart of England. Secondly, three trains per day each way are run on these lines, when one train in each direction would more than suffice for the traffic carried. Moreover, two postal deliveries and despatches daily at the smallest village possessing a railway station is the rule. And yet it is said nothing is done for Ireland! It is quite right and good policy to open up these outlying parts of the kingdom, but it is also possible to overdo it and waste money in doing so. We are not speaking without knowledge of opening up land-locked districts to civilisation when we say that if many of the present Board of Trade rules of the United Kingdom were relaxed and a little of our Colonial and Indian experience in such matters adopted much more might be done. It is absolutely certain that more economical ways of construction, equipment, and working of these so-called light railways would have been equally beneficial to the people affected, and much more so to those who provided the money, and the country at large might have had 25 per cent. greater mileage. There is no necessity to start with fencing lines through such a wild country; a cow-catcher on the engine is all that is needed at the speed travelled. There is no necessity for three trains a day each way; the amount of traffic does not warrant it, and simpler working methods without elaborate systems of interlocking and signalling and expensive stations would have been perfectly safe and sufficient for all purposes as a beginning. It is so in India and the Colonies, with a far heavier initial traffic, and it would, we do not doubt, be equally so in Ireland, England, and Scotland, but for the "iron" rules in force. It is not without knowledge that the statement is made that even in England progress with the extension of light railways to open up backward districts would be very much greater but for the impossibility of getting the Board of Trade to relax its rules in reason. We are persuaded that on the 44 miles of "Balfour Lines" alone in South Donegal a saving of £1000 per mile might have been made in construction, and a saving of from £2500 to £3000 per annum might be realised in working if more economical but safe and efficient methods had been from the first adopted.

Industrial Arbitration in New South Wales.

DURING the course of the present session we have had frequent occasion to comment on the fact that the voice of so-called "labour" is daily becoming more predominant in the councils of the State. One has only to watch the passage of the Workmen's Compensation Bill through Committee to realise that Ministers are powerless to resist the demands of those who conceive that they represent the best interests of the working man. If the protests of British employers are sounded in vain against legislative interference, it would seem that colonial employers are faced with even greater perils. We have often adverted to those measures which have been passed in New South Wales and elsewhere for the compulsory arbitration of trades disputes. The passage of the necessary statutes through the Colonial Parliament was an easy matter; but it has been found that their self-constituted tribunals do not always pronounce decrees which give entire satisfaction to the labour party. Having bent the Legislature to their will, it appears that the labour agitators of New South Wales would apply the lever to the judiciary. We read the following pronouncement of the workpeople's representative on the Bench of the Industrial Arbitration Court of New South Wales, which was circulated in the Colony a short time ago:—"A study of the series of cases [he mentions a number of cases which have apparently been decided adversely to the men] make it abundantly clear that a democracy to carry its will into effect must not rest content with placing democratic measures on the statute book, nor even with controlling the administration; they must see to it that the occupants of the judicial bench are in sympathy with the statutes they interpret. [This from a member of the Court itself One of the greatest bulwarks of conservatism and capitalism to-day lies in the fact that the judges are drawn from the most conservative members of a conservative class, and can always be relied on to lean against the liberal interpretation of democratic measures, and often to exercise considerable energy and ingenuity in actively destroying them. In stating this nothing in the way of deliberate corruption is for a moment suggested. . . . I appeal to trade unionists to come to some clear determination as to what amendments should be asked for, and urge the Labour party in Parliament to allow no business to be done in the House until the people's chamber asserts its authority to take the making of laws out of the hands of the full Court." This extraordinary manifesto fully justifies the comment of the Australian correspondent of the *Law Times*, who writes:—"The common law flourishes in a democracy, but Socialism destroys it. It sprang from the desire to protect each man in the enjoyment of his individual rights, but the collective philosophy of the present day will have none of it. The integrity of the Bench, its freedom from outside influences, and its absolute impartiality, are to give way to class bias, to political pressure, and to one-sidedness in its decisions. At least, such would be the direction in which the judiciary would tend to travel were the aspirations of some of the more advanced reformers of the present day realised. . . . The statutes made by Labour must not be interpreted or applied according to the eternal rules of justice and right as is known to the judges, but according to the will of Labour. Demos as the legislative power; the same Demos as the administrative power; again, Demos as the judicial power; finally, Demos as the executive power—such is the dream or nightmare of Labour in Australia." We trust the day is far distant when the pure atmosphere of our own courts of justice will be rendered murky by the presence of a "judicial" personage sent there to administer "justice" in accordance with the rules of Socialism.

LITERATURE.

An Elementary Treatise on Photo-topographic Methods and Instruments, including a concise review of executed photo-topographic surveys and of publications on this subject. By J. A. FLEMER, Topographical Engineer. First edition. First thousand. New York: John Wiley and Sons. London: Chapman and Hall, Limited. 1906.

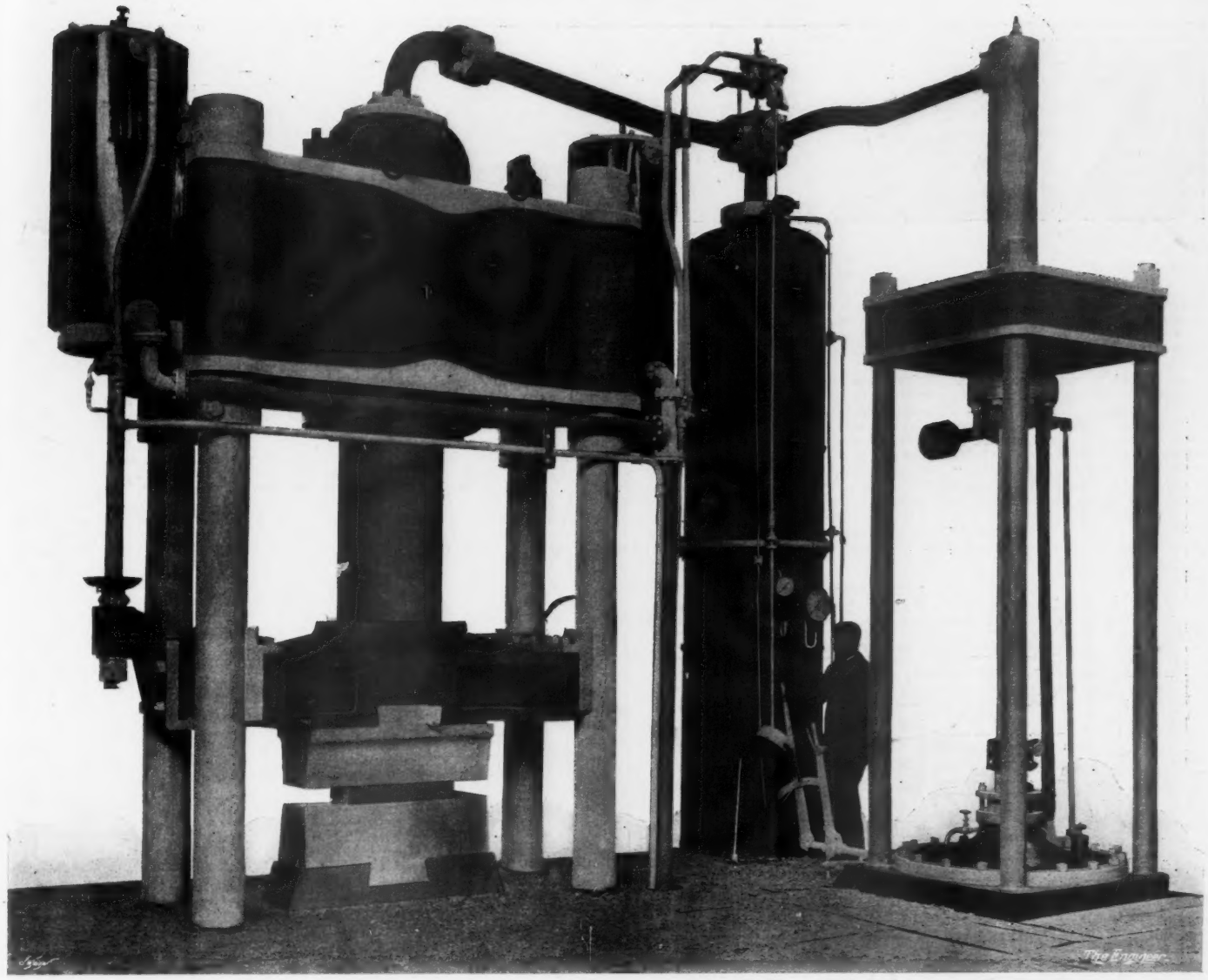
THE object of the present treatise is to describe in a general way how photography may be applied to topography, so that the result of the combination may produce a true photo-topographic survey. The utilisation of landscape perspectives for a geometrically true representation of the terrene in a horizontal plane, was rendered possible by the joint employment of surveying instruments with the modern camera. It is not necessary that the two should form a single apparatus. Independently of facilitating transportation, there are other reasons for using them separately over the same station. It should be borne in mind that the main control of the compound survey should be of a trigonometrical character. Passing over the literature and the history of the subject, and classing the contents of the volume under the heads of Methods and Instruments, we take up the first in Chapter VI. Of these methods there are two—the analytical or arithmetical, and the graphical iconometrical plotting method. Three applications of the former by different operators, including that used for the new topographical survey of Italy, are fully explained, and the necessary formulas and calculations worked out for determining the constants, elements, points and angles, indispensable to the success of the process. It should be stated that the majority of the solutions of the more important problems met with in photo-topography are given in the graphic form. A study of the five numerical examples adduced for the purpose of elucidating the relations between the elements of the photographic perspectives and the corresponding parts of the terrene, will afford the means of forming a correct idea of the degree of accuracy attained in the Italian survey.

The second method is that of graphical iconometrical plotting. Iconometry may be defined as the measuring of the dimensions of objects from their perspective views, and comprises the plotting of terrene forms directly on the plotting sheet from the photographs of the landscape. In order to plot iconometrically with accuracy topographic features, they should be observed from two or more camera stations, which are connected either directly or indirectly with the triangulation system. The number and variety of photographic surveying instruments are so great that we can only briefly allude to them. They include the primitive form resulting from the conversion of the ordinary photographic field apparatus into a surveying camera, to the best modern patterns of the photo-theodolite and photo-tachymeter. The author reports most favourably of the compound instrument designed by Mr. J. Bridges-Lee, F.R.S., which has been patented in England and other countries. It comprises a theodolite reading to minutes, a photographic outfit answering all ordinary demands, and a large azimuth compass. This combination produces a symmetrical well-made photo-theodolite, and one of the most generally useful instruments that an explorer of unknown regions can provide himself with.* The

* This instrument can be obtained from L. Casella, of 147, Holborn Bars, London.

TWELVE HUNDRED TONS FORGING PRESS

DAVY BROTHERS, LIMITED, SHEFFIELD ENGINEERS



textual description of all photo-topographic apparatus is accompanied by representations of them in many of the cix. plates attached to the volume.

The author candidly admits that, notwithstanding that photographic surveying has now become more widely known, and found practical application in several countries, yet that there are many surveyors who seriously question the practical value and general accuracy of that compound method. It is with the hope of overcoming some of the existing prejudices against photographic surveying that the treatise under notice has been written. Whether that result has been achieved will depend, to some extent, upon what degree of accuracy, what standard, what limit of error may be adopted by different readers of the book. A universal standard, applicable alike to all descriptions of surveys, would be inadmissible. A limit of error which would be perfectly justifiable in a simple reconnaissance, would allow too wide a margin in a preliminary survey, and would be *à fortiori* similarly unsuitable to the finished plan for the location and construction of a railway, or other proposed engineering work. It is correctly observed that some will hesitate in entering upon an extensive course of study, including, among other subjects, a thorough familiarity with the theory and laws of optics, photo-chemistry, descriptive geometry, perspective and general cartography, believing that without these essential aids, it is impossible to acquire a practical knowledge and comprehension of photographic surveying. While admitting that the aids mentioned will enable the student to master photo-topography in a rapid and easy manner, it is claimed that the fundamental principles underlying these methods are so simple that any topographer may readily gain sufficient theory to be fully able to apply photography to ordinary surveying. These statements appear a little contradictory, and it is just possible that the essential aids may be found rather more necessary than optional, especially in cases where the standard of accuracy is of a high character.

The elucidation of every problem is accompanied by corresponding graphic diagrams, and a careful study of the contents of the volume will enable the intending photo-topographer to master, not only the theory of the subject, but to apply it practically and successfully both in the field and in the drawing-office.

THE making of two tramway lines in the North of France—Saint Malo Terminus and Dunkerque Basse Ville—has been officially declared of public utility.

AUTOMATIC COUPLINGS AND EITHER-SIDE BRAKES.

THE Committee appointed to examine and test appliances designed to diminish danger to men employed in railway service, which consists of Colonel Yorke, of the Board of Trade; Mr. Robert Turnbull, of the London and North-Western Railway; and Mr. Richard Bell, with Mr. J. P. S. Main, assisting inspecting officer, as secretary, have now appointed Colonel Yorke chairman.

The Committee have decided to deal first with the question of either-side brakes. Such a decision was wise and safe, because of the two principal questions the committee have to deal with—automatic couplings and either-side brakes—the latter is the easier of solution. Further, it is the more pressing, as whilst wagons can be coupled and uncoupled by the coupling stick, there are no such mechanical means provided whereby a shunter can release a hand-brake from one side when the lever working it is pinned down on the other side. The question, too, has been partly solved by some companies—the Great Western for one—which have many wagons fitted with a brake that can be applied or released from either side. Then, the brake question does not introduce the complications that are connected with automatic couplings. For instance, there is no transition stage and no heavy financial outlay, nor, in the majority of cases, any question as to the stability of the wagon to carry the new attachment.

The Committee, which is to be known as the Railway Employment Safety Appliances Committee, have prepared the following regulations and conditions that have to be complied with in connection with the submission of schemes for either-side brakes on wagons of standard gauge and with a carrying capacity up to 20 tons;—

(1) The brake to be capable of being applied or released from either side of the wagon.

(2) The levers to be of similar pattern on both sides of the wagon, and the method of operating both levers to be identical.

(3) The levers to have a "press-down" and "lift-up" motion for operating the brake, with a "stop" or "rest" for each lever when in the "off" position.

(4) The levers to be capable of being operated by one hand.

(5) The levers to be "cross-cornered" and to the right of a man when facing the wagon side.

(6) The levers to clearly indicate on either side whether the brake is "on" or "off."

(7) The brake to be capable of being fitted to wagons with bottom doors.

(8) The lever handles to be not less than 3ft. and not more than 3ft. 6in. from the rail level in the "off" position, and not less than 12in. from the same level when applied to the fullest extent.

(9) The levers to be securely held or locked so as not to jar "off" or "on" by vibration or impact.

(10) The levers not to extend more than 6in. beyond the headstock of the wagon, and the leverage to have a ratio of not less than 22 to 1.

(11) The Committee will require to be satisfied that the brake can be made applicable to wagons fitted with automatic continuous brakes, utilising the same brake blocks.

As to models that are submitted to the Committee, they lay down the following conditions:—

(*a*) They must be made throughout of the same materials as the appliances or wagons they represent, and be built to a scale of not less than one-twelfth of the actual size.

(*b*) They must demonstrate clearly the principle of the design and method of working.

(*c*) Drawings—or photographs—and specifications should accompany models.

(*d*) Inventors must be prepared to attend before the Committee, if required, for the purpose of explaining the working of their appliances.

(*e*) Models should be forwarded to the Secretary, Railway Employment Safety Appliances Committee, 8, Richmond-terrace, Whitehall, London, S.W. All charges for their conveyance to and from this address must be defrayed by the person submitting the models.

(*f*) The Committee will not be responsible for the safety of the models left in their possession, nor for any damage which may occur to them while undergoing examination; and the Committee wish it to be distinctly understood that they can in no way protect the rights of inventors if the appliances have not been properly patented before being submitted.

(*g*) Inventors must be prepared to fit at their own expense their appliances to full-size vehicles for experiment, if the Committee so desire.

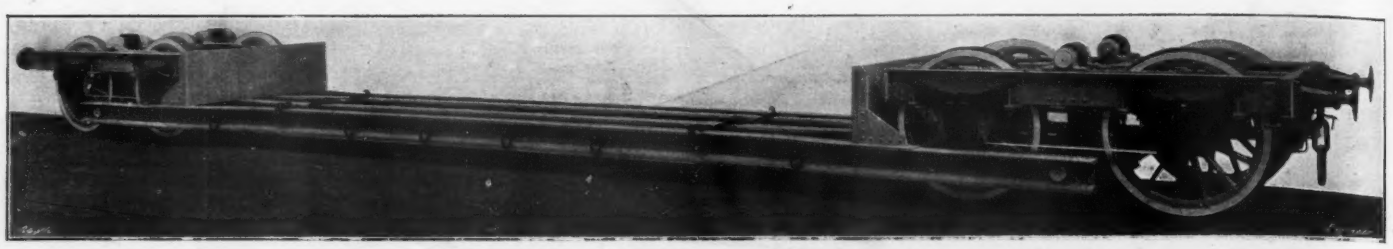
N.B.—Where full-size wagons or carriages fitted with the appliances are available, models will not be necessary, but drawings—or photographs—and specifications will still be required.

1200 TONS FORGING PRESS.

A 1200 TONS forging press has been recently supplied by Davy Brothers, Limited, to Brown Bayley's Steel Works, in Sheffield. This firm, as is well known, make a speciality of high-class steel for railway material for which very stringent tests are required, and we are informed that one of the objects they had in view in putting down this press was the probable improvement that would be effected in the steel by using it in preference to working the steel under heavy hammers. Amongst other incidental advantages we may mention the claim that much more work can be done under the press per heat and per day than under a

WELL BOGIE WAGON FOR THE CHESHIRE LINES

LEEDS FORGE COMPANY, LIMITED, LEEDS, ENGINEERS



hammer of equivalent power, with, of course, equivalent saving in labour and cost per ton of the steel handled, and that a great saving in steam consumption is effected. It is also firmly believed that cost of repairs will be very much less than in the case of a hammer of corresponding power, but the press has not yet been long enough at work to decide this point.

The whole plant, as will be seen from the illustration in the foregoing page, is very compact. The press is worked by means of a steam hydraulic intensifier embodying all the improvements that have been recently introduced by Davy Brothers, Limited, under the Holmes and Davy's patents. These features were fully described in our issue of April 27th, page 428, in the paper written by Mr. A. J. Capron on "Forging Presses," and we need not describe them again. The automatic controlling gear makes the press very easy to handle and rapid in its action, as may be gathered from the actual results obtained in working, which the makers inform us are as follows:—Lifting speed of presshead, 12in. per second; falling speed of presshead, 18in. per second; pressing speed when forging, 3in. per second; pressing speed when cutting, 4in. per second. Rapid short strokes when rounding a forging or swaging are made at the rate of 45 to 60 per minute, according to the length of the stroke. The steam intensifier makes its full upward stroke of 6ft. in 1½ seconds, and its return stroke in 1 second, equivalent to a piston speed of almost 300ft. per minute.

EXPERIMENTAL TANKS FOR JAPAN.

THOSE responsible for naval development and efficiency in Japan—in theory and design as in construction and practice—have, like the authorities in similar affairs in this country, been exercising themselves for some time about the provision of means for experimentally testing the conceptions and deductions of their designers in unbeaten paths. She is now to be furnished with an experimental tank, but it would appear that provision for it is not to be made by Government funds nor for Admiralty needs. It will follow almost exactly the lines of that at Clydebank, and of the older one established—after the Froude model at Torquay—by Denny and Brothers, Dumbarton, and, as in these cases, the Japanese tank is being established apparently by private enterprise for private mercantile needs. On behalf of the Mitsu Bishi Shipbuilding Company at Nagasaki, an order for all the necessary and highly-specialised apparatus has been placed with the firm of Kelso and Co., mechanicians and model-makers, Glasgow, who supplied nearly the whole of the equipment for the Clydebank tank, and a large proportion of that for the earlier one at Dumbarton, as well as for the tank established by Russia at St. Petersburg, and that by Italy at Spezzia.

Last year, it may be stated, the Mitsu Bishi Company produced steam vessels aggregating 18,860 tons, with machinery of over 11,000 indicated horse-power. In 1904 the tonnage was 10,500, made up by only three vessels, one of which was a twin-screw steamer of 7300 tons. In 1903 the tonnage was 14,940 tons, with machinery of 13,040 indicated horse-power. In 1902 the tonnage was 14,560, and in 1901 10,380 tons. Two, and sometimes three, steamers in most of these years have ranged from 5000 to 6300 and 7300 tons, and of correspondingly high power. Representatives have been in this country for some time, and have been allowed to study the tanks at Haslar, Dumbarton, and Clydebank. The size, general arrangement, and mechanical equipment of the new tank decided upon will more nearly approach that at Clydebank than others elsewhere. This tank is 445ft. long, 10ft. deep, 20ft. wide, and rectangular in cross section. The models there tried are generally about 15ft. long, made of paraffin wax, and shaped out from the draughtsman's design by a special cutting machine, due in its essential features to Dr. Froude. A towing carriage or gantry spans the full width of tank, and on this is grouped the gear for towing the model whilst it floats freely in the water. A dynamometric apparatus for recording results, both as respects the model and the log screws for the measuring of currents, forms the major part of the mechanism mounted on this carriage.

The carriage is a light trussed structure of wooden boxings about 4in. square in cross section, and the whole is electrically propelled. This, so far, is the only electrically-driven tank carriage in this country—the Americans, in the tank at Washington, having first adopted electricity*—motive power in the other cases being supplied by an endless rope driven from a winding engine. Needless to say, electricity will also drive the carriage in the tank to be laid down at Nagasaki, and all the most improved apparatus will be adopted which the Japanese representatives have studied at Dumbarton and Clydebank, and which the Kelso firm are in a position, from their special experience, to provide.

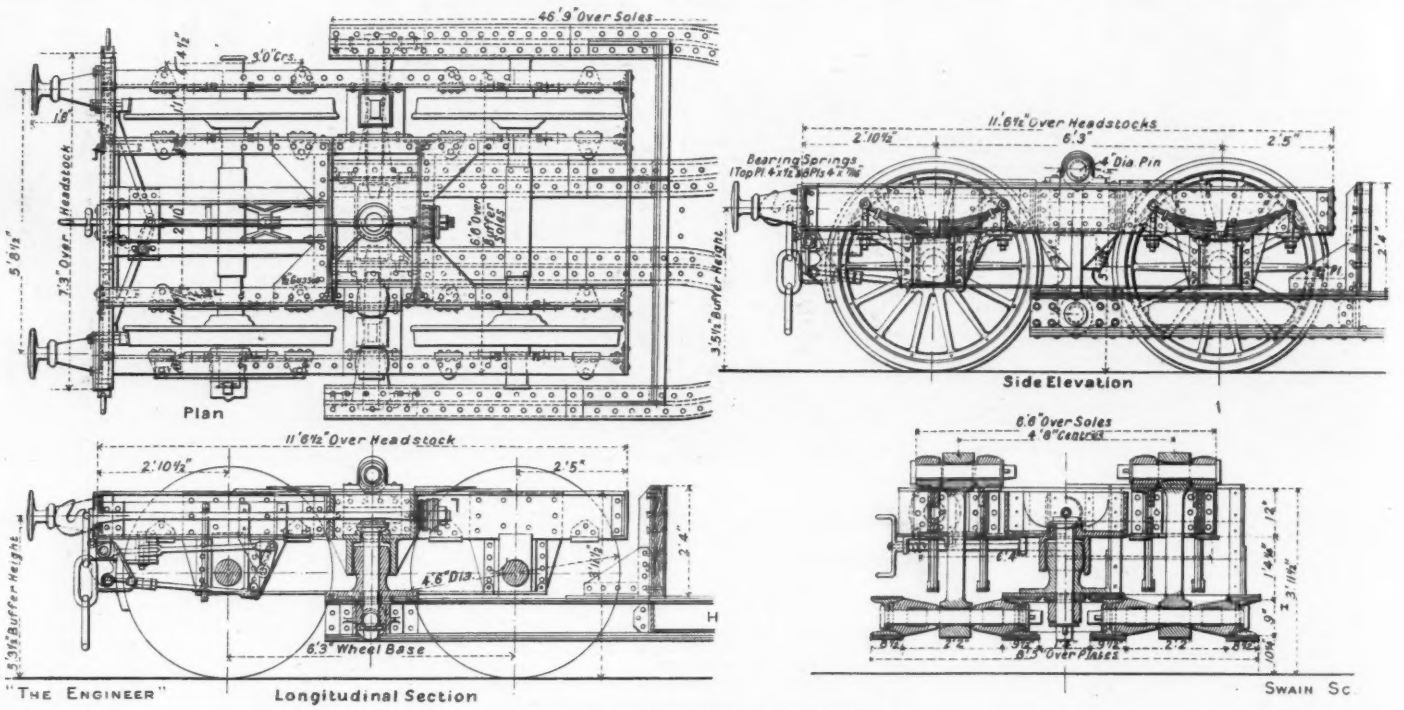
Incidentally it may also be recalled that a tank is owned by the Norddeutscher Lloyd at Bremerhaven; one has been in existence for many years at Amsterdam, one in France, and one in Washington; while the Cornell and Michigan Universities, and the Technical High School at Charlottenburg, Germany, are each equipped with one. At Paris a tank is being constructed for the use of the Admiralty and the students of the University. A tank has been warmly advocated for years as a desirable part of the equipment of the Glasgow University, and at the meeting of the Institution of Naval Architects in Glasgow in 1901 it was resolved to undertake the building and equipping of a tank to supply information to all willing to pay for it, and that it should be situated in Bushey Park, London, and be operated in connection with the National Physical Laboratory. Sufficient funds, however, have not been subscribed for it, and the project has apparently fallen through.

THE RAILWAY CLUB.—The last meeting of the Railway Club was held on Tuesday, June 12th, at No. 92, Victoria-street, S.W., Mr. G. W. J. Potter in the chair. Mr. S. Kirkwood read an interesting paper entitled "Thomas Gray and the Early Railway Systems."

* See the illustrated description of the tank at Washington in THE ENGINEER of August 4th and 11th, 1899.

40-TON WELL BOGIE WAGON.

AN interesting type of well bogie wagon has lately been built by the Leeds Forge Company, Limited, for the Cheshire Lines Committee, from the designs of Mr. J. G. Robinson, the chief mechanical engineer of the Great Central Railway Company, and is intended for the conveyance of boilers, large castings, and other loads of unusual proportions. The chief features of the design are clearly given in the drawing and the engraving above, and the following are the leading dimensions:—Length, over buffers, 59ft. 3in.; width, over headstocks, 7ft. 3in. The length of the well is 32ft., and its width 7ft. 5in. The distance from rail level to the floor of the wagon is 1ft. 8¼in. There are two four-wheeled bogies, the centres of which are 44ft. 9in. apart. The wheels have a diameter on tread of 4ft. 6in., and the bogie wheel base is 6ft. 3in. The journals, both on inside and outside wheels, are 8in. by 5½in.; the centres of journals are 6ft. 4in. apart.



40-TON WELL BOGIE WAGON—DETAILS OF BOGIE

The buffer height is 3ft. 5½in., and the centres of buffers 5ft. 8½in. If loaded to its full capacity the wagon will carry 40 tons, but if loaded with a central space of 12ft. the carrying capacity is 25 tons. The wagon is fitted with a hand brake on one bogie only, applying one block to each of two wheels.

CONTRACTS.—An order has just been secured by John I. Thornycroft and Co., Limited, from the West Bromwich Corporation for a 24-horse-power motor fire-engine tender to carry ten firemen together with a certain amount of fire-extingui-hing appliances. Orders for similar chassis have also been received by this firm from his Grace the Duke of Portland, and the National Electric Construction Company.—The New South Wales Government have accepted the tender of Dick, Kerr and Co., Limited, for two 450-kilowatt rotary converters similar to those supplied by the same firm under the original contract. This firm has also secured contracts for one 1600-kilowatt alternator for the Bolton Corporation Tramways Committee, one 250-kilowatt generator for the Stoke-upon-Trent Corporation Tramways Committee, and one 275-kilowatt steam generator for the Kilmarnock Corporation Tramways Committee.—Messrs. John I. Thornycroft and Co., Limited, Woolston Works, Southampton, have just concluded a contract with the Indian Government, for the Commissioners of the Port of Calcutta, for seven twin-screw ferry steamers for service on the Hooghly, through their London representative, Mr. J. H. Apjohn, M.A., M. Inst. C.E.—We are informed that the Underfed Stoker Company, Limited, of Coventry House, South-place, Finsbury, E.C., has received several orders for the equipment of water-tube boilers. Among these we may mention the contract to equip two Nesdrum boilers belonging to the Charing Cross, West End and City Electric Supply Company, Limited; the equipment of three Babcock boilers at Messrs. Spiers and Pond's; and two Stirling boilers at David Colville and Sons, of Motherwell. For internally-fired boilers the firm has received contracts to fit eight Lancashire boilers for the Hull Corporation Electric Lighting Works; nine Lancashire boilers for the South Wales Electrical Power Distribution Company; and many other smaller orders.—We understand that Messrs. Joseph Allen and Sons, of Sheffield, have secured the War-office contract to supply 65,000 razors of regulation pattern.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

NAVAL STOKERS AND NAVAL ENGINEERS.

SIR,—The recent visit of a few M.P.'s to the Devonport training establishment for mechanicians induces me to venture a few remarks on the subject of the displacement of engine-room artificers by stokers, and the subsequent effect this will have, first, upon the two classes of men concerned; and, secondly, upon naval engineering generally.

As your readers very well know, engine-room artificers have hitherto been recruited, as already trained mechanics from the workshops of the country, and the conditions under which they entered were that they would become the engineering watch-keepers of H.M. service, in addition to attending to any repair work that might become necessary. So much importance has always been attached to their former work—engine-room watch-keeping—that it has been the pivot upon which their future advancement in the service has been dependent. Further, this duty has been, and is, regarded of such importance in the naval service that certain watches—by no means superior in importance to others that recur in the twenty-four hour day—have to be kept by the engineer officers. In the mercantile marine liners watch-keeping is the exclusive prerogative of engineers, whose conditions of entry approximate to those of the naval engine-room artificer, *i.e.*, these officers are trained, first, in the mechanical arts of engineering in the workshops of the country, and, at the close of this apprenticeship, learn the greater business of marine engineering.

My object in the immediately foregoing remarks is to bring out the point that, to be in charge of the engine-room watch is regarded by the engineers as one of the most important and fundamental duties of the profession. The ordinary lay mind may not quite grasp this, but it is a *sine qua non* amongst engineers, and all who possess the intuition and inwardness of the true engineer and who fully realise what is involved in the term—charge of a watch—in a modern man-of-war. Now, the engine-room artificers, by the provisions of the Cawdor Memorandum, are to be divorced from this, to them, important and integral part of their duty, and, in so far as it has practically made engineers of them in the past, it has to be permanently surrendered. The Douglas Memorandum, page 155, even proposes to eliminate from their present titles "engine-room," and "engineer," so that the engine-room artificer will become an artificer pure and simple, and artificer engineer a warrant artificer. The result is a consequent, and—amongst engineers—a well understood and reasonable cause for complaint, and a source of intense dissatisfaction amongst the men.

Here are men who, in view of the openings offered in H M. Navy, have foregone appointments they might have had in the mercantile marine, and their reward for so doing is a permanent relegation to repair work; in other words, they are to become permanent mechanics, whilst the stokers whom they are training will enjoy the superior position of watch-keepers.

The engine-room artificers have no lofty imaginative flights. They are as willing and ready as ever to do their mechanical and repair work, but they do feel most acutely the setting back that is being given them, for no apparent reason. From all quarters, high and low, come expressions of commendation for the manner in which these men have hitherto conducted themselves, and remarks of regret that such undeserved treatment is being accorded them. This makes the situation all the more puzzling when the cause is being searched for.

Stokers and engine-room artificers practically join the service at a similar age; in other words, as men, and this point must not be lost sight of by those who repeatedly emphasise the word discipline. The former is not required to possess any mechanical or technical knowledge whatever; the latter has to prove his mechanical skill by performing his trial job, and has to pass a theoretical examination in engineering, &c., subjects. The incongruity of the thing becomes clear when one is thus brought face to face with the fact that the stoker, after receiving training at the hands of the engine-room artificer, is himself to jump to the superior position, for superior position it surely is, notwithstanding even Professor Ewing's inspired assurances.

Now, the engine-room artificers have nothing whatever against the stoker. They well know and appreciate his worth, and are glad that he is at last to enjoy promotion to warrant rank equally with the ordinary upper deck seamen. But to give the stoker promotion at the expense of the engine-room artificer is such a gross injustice and violation of every principle of right and equity, that it cannot possibly be expected that the proposal can be accepted with anything like equanimity. Its result is, and will continue to be, an upheaval of discontent that will take some quelling. The stokers themselves, as a body, are not pleased at the prospect, and the seeds of discontent are already developing in their ranks, for the very reason that only about 16 per cent. of their number can hope for any benefit from the scheme. The age limit for promotion to mechanician and warrant officer shuts out all those most fitted for advancement, and who have already borne the burden and heat of the day. Not only so, but the emoluments hitherto enjoyed by stokers of ripened experience are to be given to younger men. Hence these, with many other causes that might be cited, are a fruitful ground for bitterness amongst the larger portion of the stokers.

May I enforce the point that there is no earthly reason why engine-room artificers and stokers alike should not equally receive consideration, and that likewise there is no possible reason why they should be brought into competition with one another at all? Let the engine-room artificers remain under the conditions of the Selborne scheme; assign to them their proper [illegible] in the engineering economy of our ships; encourage that [illegible]irit which they manifest in their desire to keep abreast of [illegible]ive as many stokers as possible warrant rank, without [illegible]riction in the one class or that of the other; to the larger [illegible]ber of stokers grant the progressive pay and increased pensi[illegible] I venture to assert that the British Navy will be richer [illegible] equipment and effectiveness than it can possibly be with dissension, jealousy, strife, and discontent tearing away at the heart-strings of the men below.

But beyond all looms the question of an efficient Navy. Will the substitution of the two-year specially trained stoker, at 25-30 years of age, make our engine-rooms more efficient and inspire the officer on the bridge with a greater confidence in the effectiveness of his warship? Will our fleet at tactical exercises be less immune from accident under the new regime than it is now? Will the fact of breakdowns occurring in engine-rooms, under other conditions, make the repairing agents as eager to perform their repairs effectively as they now are, when, as watch-keepers, they are more or less immediately responsible for breakdowns? Will the principle still stand good that to prevent accidents is infinitely better than to remedy them, and is it likely that a fully-trained mechanical intelligence on the engine-room platform will be less capable of understanding the inward throbbings and troubles of a pair of engines, and of anticipating the remedy, than the trained stoker will be? Is not one of the functions of the repairer to-day that of location—diagnosis? Has he not frequently to find out the trouble ere he remedies it, and does not our engineering experience repeatedly teach us that it takes the hourly attention of the skilled mechanic to prove his hidden difficulty, and if this be so, is not the engine-room platform the proper place for the mechanic, and *vice versâ*? Will anything less than the very best do for the British Navy, and does the nation expect its men-of-war to be served less efficiently than its mercantile marine, where every responsible official below is a fully equipped and trained mechanic? Will we be far wide of the mark in the opinion that the best engineers afloat to-day do not subscribe to the new order of things, and that the few selected engineer officers whose opinions are recorded do not speak for them? These are questions which, in my opinion, are worth the answering by some of your readers, and as I have already prolonged this letter to an almost unpardonable length, I will conclude by asking the final question—How will the provisions of the new scheme not interfere with the promotion of engine-room artificers to artificer engineers, and how will the matter of the stoker taking charge of the artificer in his own immediate realm be obviated?

ENGINEER.

June 12th.

SIR,—Your correspondents somewhat misunderstand the position I take. For instance, for what reason on earth should I want to "imply sneers" at the artificers? All I seek to do is to sort out the various issues involved. To resort to tabulation, the matter works out like this:—

(1) The change as it affects naval efficiency.

(2) The change as it affects the position and prospects of the artificers.

Now, in all the arguments that I have read, these two things have been inextricably mixed. They ought not to be mixed. To be honest, I should add that I am not concerned with (2), except in so far as it is compatible with (1). To naval efficiency everything else must break or bend.

And here comes the rub! The artificer would be—which he certainly is not—a born fool not to try and show any change apparently prejudicial to his interests to be prejudicial to efficiency; but in a general discussion on the matter this form of special pleading ought to be left out. We ought to discuss the matter solely from the naval efficiency standpoint.

Now, I am quite sure that your correspondents will allow that an improvement in the prospects of stokers makes for naval efficiency.

In some correspondence on the subject the stoker has been unjustly pictured. Correspondents with no knowledge of the Navy have taken the mercantile marine fireman as a sample of the modern naval stoker; others have drawn on their knowledge of stokers a couple of decades or more ago. "Ne'er-do-weels" are very scarce indeed in the actual force, and nearly all I have ever come across are owners of a succession of "V.G.'s." There may be others not after that pattern, but they have no ghost of a chance of warrant rank, and so do not come into the present discussion. And—I know many of my friends, the stokers, pretty intimately—when I stated that their average all-round mental ability was equal to that of the average artificer, I meant what I said. "Ex-Engine-room Watch-keeper" misunderstands my meaning, however, for he tends to mix it up with mechanical ability, which is, of course, quite another pair of shoes! I refer entirely to mental ability outside professional subjects. Confront a dozen of each with some absolutely novel idea, and as many of one class as of the other will pick it up. Past correspondence, however, has too often implied that the stoker is inevitably a brainless ass. That is a libel on the stoker. But I do not think my saying this should be construed as a "belittling of the artificers." Why on earth should I wish to belittle them!

Now, about the "dry nursing." The favourite argument put forward by opponents of the new system is that "the artificer is a highly-trained man who costs the country nothing for his training." Now that, to any lay mind, suggests naturally that he enters fully competent to run engines, and all the rest of it, knowing his way about the ship, and conversant with naval routine—and that is an entirely wrong conclusion. As "Ex-Engine-room Watch-keeper" admits, the artificer has to be "dry-nursed" like every one else. When he enters he is a skilled mechanic—a boiler-maker, fitter, moulder, or what not—but he is not, at entry, a navy man; so the country does pay something to train him as a navy man. Usually two years are spent in teaching him to run engines.

Now, the artificer who originally entered for repair work and engine-room watch-keeping was a diversion from his original *rôle*. He was found to be excellent material for it, but his services were obtained at the expense of his own particular original job. The new system is training the pick of the stokers to do the watch-keeping, and allowing artificers to revert to what they were enlisted for, and what they alone can do.

So it really comes to this: An artificer who is a skilled fitter or some such trade entered the Navy, and was trained in two or three years to engine-room watch-keeping. Under the new system the country will get the benefit of him at the occupation to which he was trained outside. The pick of the stokers, after some six years' service, will have the same training, and surely be able to do the watch-keeping work. Surely no one is going to argue that early training as a coppersmith or fitter is essential to the running of engines. As a result, minor repairs and attention to auxiliary engine repairs will no longer have to be neglected because the mechanics are "otherwised engaged."

To call this "wrecking the Navy" is indiluted rubbish. Having said this, I will quite readily admit that it may upset trades union ideas; but I believe in Navy before trades union interests. Also I admit it upsets certain artificer aspirations to secure positions equal to those occupied by their brothers in the merchant service; but as there was never the slightest prospect of those aspirations being granted, what use crying over spilt milk?

The present pay and actual prospects of the E.R.A.'s are in no way interfered with; indeed, so long must elapse before the new system becomes operative that most present E.R.A.'s will be absolutely unaffected. Whence, then, all the pother? Heaven only knows, except that the "despicable clique" to which I have referred in the past, and—with apologies to "Another Engine-room Watch-keeper"—refer to again, set the ball rolling, and honest critics like my correspondents are trying to pull the clique's chestnuts out of the fire.

Portsmouth, June 16th. FRED. T. JANE.

P.S.—I shall be away at the manœuvres, and so unable to reply to further correspondence for two or three weeks, but thereafter I shall be quite happy to go on with it on definite grounds as concerns naval efficiency. But let us have done with invidious comparisons between artificers and stokers, and discuss it only as Navy *qua* Navy. Outside that I am not unsympathetic, but I adhere rigidly to the principle of "To naval efficiency everything else must break or bend," be the cost to individuals what it may.

SIR,—I should like to reply to Mr. F. T. Jane's letter in your issue of June 8th. Does he think that all of the six hundred men who joined the Engine-room Artificer Branch of the Royal Naval Reserve would have done so if they had been made aware of the new scheme for making stokers into warrant officer watch-keepers? These men, who hold Board of Trade certificates as engineers, many of whom are, and have been for the past ten years or more, in charge and responsible for the upkeep of machinery and boilers in ships sailing the world over, if called on in emergencies, are to find their orders are given to them by the stoker watch-keeper.

Will Mr. Jane say that these engineers will require dry nursing by chief stokers, either in their engineering duties or obedience to superior officers? While doing their month's training they proved they were not lacking in these matters, and did not require or receive tuition in such. Who knows better than a marine engineer the position and responsibility held by the watch-keeper—he is the man to know what repairs are necessary, and the simple fact that he will have to take charge of his own repair work speaks for itself. What greater incentive can he have for good workmanship than this? There is a vast difference between a stoker taking charge of a steam pinnace and the engines of a 20,000 horse-power battleship. They are, no doubt, very worthy men, but my personal experience of them is that the greater majority are a very long way behind in the most elementary theory of steam and steam engines.

The Board of Trade have not thought fit to allow stokers to sit at their examinations, and shipowners would not care to pay the extra insurance money which would most surely be demanded if stokers were allowed to keep a watch. The Admiralty have had great trouble in getting youths to join the stoker branch, which proves they cannot pick and choose as they might wish. If the stokers were given the warrant rank with its extra pay, and were confined in their duties to the stokehold, no dissatisfaction would be heard, and I am quite sure that this is all they want.

London, June 13th. E.R.A., R.N.R.

THE LATE MR. F. W. WEBB, AND COMPOUND LOCOMOTIVES.

SIR,—Your correspondent "F. A. L.," in his desire to defend the engineering reputation of the late Mr. F. W. Webb, has made an unjustifiable and violent attack upon other people, and as his remarks, if uncontradicted, are calculated to mislead, I ask you to allow me to make a few comments on them. I knew Mr. Webb well; I know "F. A. L." also well; and I have had better opportunities than he has of knowing the real facts of the case. I have no desire to disparage Mr. Webb or to enter into any controversy respecting the merits or demerits of the principle of compound locomotives, but I think it is advisable to correct the mistaken opinions set forth by "F. A. L.," so that your readers may not be led astray. I am quite sure Mr. Webb would have repudiated some of them.

Mr. Webb did no harm in experimenting with the principle of compounding; his error was in building a large number of compound engines upon insufficient tests. It is a reflection upon his mechanical engineering discernment in adopting the principle for locomotive work. His mistake proved a most expensive and troublesome one for the London and North-Western. The greatly increased cost of construction of his compound engine over that of the simple type was a considerable item, while the greater number of wearing parts and the rapid deterioration of the engines which took place in consequence of their unsteady running caused them constantly to frequent the shops for repairs, which added largely to the account of unprofitable expenditure. The small saving that was claimed in fuel consumption was a negligible quantity. In addition to this, they were incapable of dealing with the traffic requirements. They could not haul the loads wanted nor keep time with the trains to which they were attached, and loud complaints arose from passengers in consequence. They were slow in starting, and did so with an unpleasant jerky action. It was found necessary at the principal stations to have a light engine in reserve to give the trains drawn by the compounds a push behind for a given distance in order to get them out of the stations, and many of the express trains had to be run with two engines. These are indisputable facts, and they gave rise to smiles of derision in the railway world.

"F. A. L.," in the face of this state of things, has the audacity to call in question the steps taken by the general manager, whom he designates "unchecked autocracy," to remedy that extremely unsatisfactory state of affairs. He speaks of these efforts as "an open and covert campaign of hostility towards Mr. Webb," and, in the eyes of "F. A. L.," it would appear to be sacrilegious either to question or interfere with what Mr. Webb might choose to do. It does not seem to cross the mind of "F. A. L." that the "supreme head" has duties to perform, and that the chief one is to see that the interests of the shareholders of the London and North-Western Railway are protected to the best of his ability, and that no head of any department shall be permitted to continue a mistaken and wasteful system. In this case it was evident that the compound engines were affecting alike the interests of the company and the public. It speaks well for the forbearance of the general manager of the premier railway of the world that he tolerated as long as he did the obstinate adherence of Mr. Webb in constructing locomotives on his compound system. "F. A. L." says that the opposition of Mr. Webb to the demand for reform was because he "naturally resented the ill-advised and unknowing interference with its—the Locomotive Department—affairs, which he quite properly considered himself the most competent person to deal with." Such confidence, however, can only be accepted in an infallible person, and there is no engineering Vatican. It was fortunate for the North-Western that the general manager was able to put an end to the reign of the "compound" blunder.

It is true that the traffic requirements are very heavy, but this pressure is caused by having to meet the constantly growing demands of the public. Mr. Whale, who has succeeded Mr. Webb, has, in the short space of a couple of years, almost revolutionised matters. He has built engines capable of coping with requirements. He has returned to the simple engine, but built it powerful enough to take the trains formerly requiring two engines when run by Mr. Webb's compounds. In this way an enormous number of unnecessary engine miles, which would be run if a second engine were employed, are saved, and the company must be benefiting to the tune of thousands of pounds per annum by the use of Mr. Whale's single engines, whilst the timekeeping has been vastly improved.

I hope my remarks may dissipate the wrong impressions the letter by "F. A. L." may have raised.

June 19th. LYNX.

HIGH SCHOOL OF TECHNOLOGY.

SIR,—I am directed by the Council of the above Association to forward to you the following resolution passed by the Council respecting the proposed High School of Technology at South Kensington:—

"The Council welcome the establishment of a Technological High School at South Kensington on the lines laid down in the Departmental Committee's report, but suggest that the following points be considered before the report is embodied into a concrete scheme:—

"(1) The work of the institution should be confined to technical investigation, research, and post-graduate studies as defined in Section 88 of the Committee's report, and no training preliminary to the true work of the institution should be undertaken in the new college. Some of the highly specialised departments should be situated at more convenient centres in the provinces, and full use should be made of the staff and equipment already existing in such towns as Manchester, Leeds, Sheffield, Newcastle-on-Tyne, &c. There should be due co-ordination between the work of existing technical institutions and that of the new suggested institution, especially in regard to the earlier training of students, to fit them to profit fully by the advantages offered in the highly specialised departments of the school at South Kensington and elsewhere.

"(2) The conditions of admission should be so framed that the minimum age of students entering the school should be nineteen, and all students should be required to give evidence of previous satisfactory training for three years after having reached the standard of general education marked by University matriculation. This can be easily secured if a suitable scheme of co-ordination work be arranged among the technical institutions. An honours degree in science of a British or Colonial University should also be accepted as qualifying for admission.

"(3) Owing to the large amount of public money to be utilised in the establishment and maintenance of the new institution, there should be a greater element of public control on the governing body than is suggested in Section 95 of the Committee's report. Further, there should be representatives from associations connected with technical education, in order that the continuity of a student's work can be secured. This Association endorses the recommendation of the majority of the Departmental Committee that the governing body should be appointed at once, and in the first instance, for a period of five years.

"(4) This Association is of opinion that the new institution should be permanently independent of University control."

J. WILSON, Hon. Secretary.

Association of Teachers in Technical Institutes,
June 6th.

THE FAILURE OF CHARING CROSS ROOF.

THE report of Major Pringle, R.E., on the failure of the Charing Cross roof, South-Eastern and Chatham Railway, has just been issued. As most of the facts have already been published in our issue of January 12th, 1906, it is unnecessary to do more than reproduce the technical evidence intended to explain the cause of the catastrophe. The report contains diagrams, which we reproduce, and we also reprint a photograph of the section of the bar which escaped oxidation after fracture.

Mr. Percy Crosland Tempest, M. Inst. C.E., chief engineer of the Managing Committee of the South-Eastern and Chatham Railway Companies, and as such is primarily responsible for all engineering structures, in the course of his evidence, said: I have known Charing Cross Station for twenty-five years, and have had charge of it from 1895. I had charge of it from 1895 to 1899 as resident engineer, and from 1899 onwards as chief engineer. The station roof was designed by the late Sir John Hawkshaw, and was completed about the year 1863. It was built by an independent company which was amalgamated with the South-Eastern Railway Company in 1864. The station is vested in the South-Eastern Railway Company and managed by the Managing Committee. The type of roof is a crescent trussed bow-string, supported on side walls. The length covered by the roof before the collapse was 510ft., and the clear span between walls is 164ft. There are fourteen main principals and one screen girder at the south end. The distance from the wind screen to the first principal north is 41ft. 6in. The width between the first and second principals is 37ft., between the second and third 36ft., and the remainder are 35ft. apart. These dimensions are central. Each principal is carried on pilasters which rest on a brick viaduct. The side walls between the pilasters are filled in with brickwork in mortar. I put in a plan showing the dimensions of the brickwork and the heights. It is 45ft. from the top of the side walls to the level of the crown of the roof, the maximum depth of the truss being 20ft. The end screen consisted of a box girder with an ordinary built up plate flange for the bottom member, tie-rods not being used. The ends of this girder rested on the two southern pilasters, and were placed at the same level as the footings of the main principals. The width of the box girder was 3ft. It was not stayed in any direction southward. The ironwork was constructed by Messrs. Cochrane, Grove and Co., and the iron came from Lord Dudley's works. At the south-east end of the station there are buttresses which support a tank. I have no reason to believe that they were built for any other purpose than to carry the tank, but they add considerably to the stability of the wall at that point. There are no buttresses at other portions of the wall. The buttressing of the south-east end was carried out at the time of the construction. The main rib which collapsed weighed 17·26 tons. Including the weight of the rib, the portion of the roof carried by the principal which fell weighed 63·16 tons, or 18·4 lb. per superficial foot, the actual area of roof supported by this principal being 200ft. by 38·6ft., or 7700 superficial feet. To this must be added the staging supported by it, which weighed 17·41 tons. Therefore, the total dead load carried by this principal prior to its failure was 80·57 tons, or 23·4 lb. per superficial foot of roof area. The design of the roof is that of a contained arch. There is no thrust on the walls, the pressure being vertical. The scantlings of the different members of the principal which fell were: purlins, four angle irons, 3½in. by 3in. by ⅜in., purlin lattice bars, 2in. by ⅜in., purlin bracings or common rafters, two tee-irons, 5in. by 3in. by ⅜in., lattice bars of the common rafters, 2in. by ⅜in.; main rib, top boom, four angle-irons, 6in. by 3in. by ⅜in., web plates of main rib, 18in. by ⅜in.; tie-rods, middle bay 4½in. diameter, next bay 4⅜in., next bay 4½in., next bay 4⅜in., and the side bays 5in.; panel counter bracings, flat bars, 4in. by ⅜in.; panel verticals, two tee-irons, 6in. by 3in. by ⅜in. I hand in three diagrams showing the stresses (1) due to weight of roof only, (2) due to roof and staging, viz., 80·57 tons, equivalent to 23·4 lb. per superficial foot, and (3) the stresses on a normal principal with the central interval of 35ft., which would result from the test load of 127 tons distributed, which was applied at the works before erection. This latter weight is equivalent to a load of 40·7 lb. per square foot of roof area supported. The additional weight carried by the principal which fell owing to the staging was 17·41 tons, including men, tools, canvas sheets, and zinc, &c. The staging, with the exception of that under the lantern, weighed actually 27·43 tons. This includes everything, men, tools, and materials. From this amount a deduction of ·8 ton must be made on account of the glass which it was necessary to remove before the hangers could be put up. The main stage therefore weighed 26·63 tons. The centre stage under the lantern weighed 5·38 tons. Therefore, the total additional weight on the roof due to staging, materials, men, &c., was about 32 tons. To arrive at the weight carried by the principal which fell, I resolved the weights according to the points at which they were carried by the hangers, and this gives a load of 17·41 tons of staging carried by No. 1 principal. From the diagram of stresses which I have handed in it will be seen that on the tie-bar which broke the stress in tension amounted to 81½ tons. The area of the bar as erected was 15·9 square inches. Therefore, the stress in tension per square inch of the whole area was 5·13 tons. The weight of staging carried by the principal at the time of its collapse amounted to approximately 5 lb. per square foot of roof area. The factor of safety in the tie-bar which broke, assuming an ultimate strength in tension of 20 tons per square inch, was therefore 3·89. A similar staging was put up eight years ago, and the stresses therefore would be identical at that time. Considerably heavier weight in the shape of staging was placed on the roof about 37 years ago, after a fire on the station platform. I have calculated that a horizontal wind pressure of 40 lb. per square foot, in addition to the dead weight of the roof, would bring a tension stress on the tie-bar in question of 5·71 tons per square inch. I have also calculated that a horizontal wind pressure of 27 lb. per square foot would give the same additional stress in tension on the bar as that due to the staging. As regards inspection, there are no fixed periodical inspections, but the roof is constantly under observation—both the roof and walls. There are always men working on the roof. They were practically there every week, and they had instructions to examine wherever possible, and report anything they noticed to be wrong with it. The walls were walked round daily by the foreman bricklayer in charge of the London district, and any movement would have been at once reported. The district engineer also visited the roof twice a year. It was an examination made in the best possible way without a staging. When the roof is painted and scraped, it is very carefully examined, and in addition there is one special inspection made between the periods of re-painting.

After describing the nature of the supervision carried out he went on:—

I think there is only one possible theory to account for the collapse of the roof. The tie-rod which broke showed a bad flaw caused, as subsequent examination has demonstrated, by an imperfect weld, and it is not necessary in my opinion to look further for the cause of the collapse, although I have considered it from every other possible point. The different lengths of the tie-rods, which are about 18ft. long, have screwed ends which are fitted into muff couplings situated at the bottom of each of the vertical members of the truss. From careful examination in the testing room of other ends of similar bars, it is fair to assume that these screwed ends have been attached to the main body of the tie-bar by a scarf weld, and it was one of these welds which gave way. The fractured section revealed the fact that only a small proportion of the area of the metal of the bar had been doing its work, and that is a complete explanation of its failure. It is very difficult to say how much of the metal was actually in contact in this rod at the time of the collapse, but speaking roughly I should say a little more than one-third of the bar was doing work. This would reduce the available section to between 5in. and 6in. The weld was in no way affected by rust or corrosion. The loss of diameter in the tie-bar due to rust was $\frac{1}{10}$in., so that the tie-rod, instead of being 4½in. in diameter, as when erected, had at the time of failure a mean diameter of 4·4in. The bar in question was not truly circular. There is nothing to show that there has been any fatigue or change of structure in the material away from the weld. The metal in the bar behind the fracture, when tested, showed an ultimate strength of about twenty tons to the square inch in tension. The fracture shows that over its area the iron was in metallic contact at isolated points round the circumference but not in the centre. I was not aware—until some time after the accident—that the screwed ends of the tie-rods were welded to the bars. It was only after following the experiments at Messrs. Kirkaldy's works that this was demonstrated. As regards Cannon-street Station—although the design is generally similar—there is a much greater margin of strength. The walls are 50 per cent. thicker, and the truss members as much stronger than in the case of Charing Cross.

Mr. William George Kirkaldy said: I received first the west end fracture of the tie-bar, and afterwards also the east fracture with a moving coupling attached. I was asked to make examination tests. First I examined the bright fracture. It had to me every appearance of a weld, and of being defective in the centre part. There is a trace of cinder in the very centre of the fracture. I felt that although it had all the appearance of a weld I must keep an open mind and endeavour to prove conclusively that it was a weld. There was, perhaps, I thought, some other explanation of it. The line of fracture is at a blunt angle, and that is one of the reasons why I considered it likely to be a weld. I cut off the bright fractured bar about an inch behind the actual point of fracture; I then took a piece off the stump end that was left and treated it with acid. This showed to me the method of manufacturing the bar. There were eight slabs of iron piled one on top of the other. This constituted the bar itself. On the face of my cut nearest the fracture I found, after treating it with acid, there was a disturbance in the layers of iron which made the bar, and it appeared as if this was a continuation of the line of what I considered was the weld. This disturbance was not visible at cut No. 2, which simply showed the marks due to the piling of the rod. The disturbance shown on the cut nearest the fracture strengthened my idea that the fracture had taken place actually at the weld. I still had to bear in mind that, although this was evidently a weld, it might not have been an intentional weld. I thought that if it had been an intentional weld I should find traces of a similar weld at the other end of the bar near the coupling; on the other hand, if it was only a chance weld the other end of the bar would not show any sign of welding. The result of my first careful examination of the exterior of the other end of the bar was that I could find no sign of any weld. Then I cut off about 20in. of the bar, and turned a portion of it in a lathe. After reducing the diameter in the lathe considerably, I found distinct traces of a weld. The result of this examination in a lathe was to prove to me that the bar was of set purpose welded at both ends. I thought it was quite possible for the smith to have set up both ends of the bar from the solid for the screw ends, but having found welds at both ends I thought it was clear that, owing to the length of the bar, about 18ft., it was not possible in those days to turn the bar in a lathe, and that for that reason the screw ends were first of all manufactured, and these ends then welded on to the bar. When I had an opportunity, before making these tests, of seeing the iron work that had fallen, I examined several of the bars very carefully, but could find no signs of any weld on any of them, and this was the reason that, though I had made up my mind that the actual fracture was at a weld, I was concerned to find out whether it was a chance weld or an intentional one. I obtained from the engineer of the company several additional bars with which to continue my investigations. In the case of the three bars that I examined, by scraping off the rust down to the clean surface of the metal I found at one end only of each of the bars traces of a weld. The marks were 1in. to 1½in. in length, and had the appearance of a raised fibre on the surface. In no case was there anything of a crack at the weld. I failed altogether to get any trace of a weld at the other end of each of these bars. I turned off a portion of the metal in a lathe, and I then found the mark of a weld on the bright surface of the metal that was exposed by the tool, but in no case was there any visible crack or cavity. The result of the examinations that I made of these bars clearly proved to me that they all had welds at each end. Possibly, therefore, it is a fair inference that all the other tie-bars in the roof were similarly manufactured, for until I had examined these other bars there was always the possibility that the welds in this fractured bar were due to chance only. Looking at the west fractured end of the bar, the clear crystalline portion was solid at the time of fracture. This bright metallic surface was approximately the upper side of the bar in position. I think that, in addition to the bright surface, the remainder of the discoloured surface round the circumference was at some time or other also in contact and adhering. I gather this from the fact that this discoloured portion has still a sharp grain when touched, and in addition to this you can see spots here and there on the circumference and nearer the centre of a metallic brightness. The actual centre of the bar has a different appearance, and has evidently never been in contact. This portion is defined by the ash which surrounds the core, and the core itself has a smooth undulating surface with a fire skin on it. The iron of which the bar was made may be described as good quality iron. I cut out two round iron test bars from the bar that broke, about 6in. behind the fracture, and tested these for tension. These two bars broke under an approximate tensile stress of about 20·6 tons per square inch. The contraction of area in each case was over 40 per cent. The solid portion of the bars had all the character of new iron. There was no sign of any deformation or deterioration due to fatigue. The result of a number of measurements of the circumference of the bar that broke showed that 4·4in. would represent the mean diameter. The waste due to rust or corrosion amounted, therefore, to $\frac{1}{10}$in. on the mean diameter. I made other tests of the metal surrounding the weld at the other end of the broken bar, and found generally the same results—namely, high tensile strength in the solid portions, and nearer the centre, where the welding was less perfect, the tensile strength diminished, until quite in the centre where the cavity existed there was no tensile strength. I tested two other tie-bars after reducing the areas in a lathe to 8 square inches, and found that the breaking tensile strength of these two specimens, each of which contained a weld, was 11·15 and 12 tons respectively on the square inch. In these two cases there were similar pockets to those found in the tie-bar which broke. Two other specimens, also amounting to 8 square inches of the central portion of the bar, broke at 14·1 and 17·3 tons per square inch respectively. The fracture in these cases was also through the weld. In these four cases the metal that was turned off in the lathe to reduce the area of the bar was in each instance sound and good. I do not think any heat, such as would be necessary to burn off paint, would have any deteriorating effect upon the quality of the iron of the tie-rods. I think that the centre portion of this tie-rod was never in contact.

BROKEN END OF TIE ROD—ACTUAL SIZE

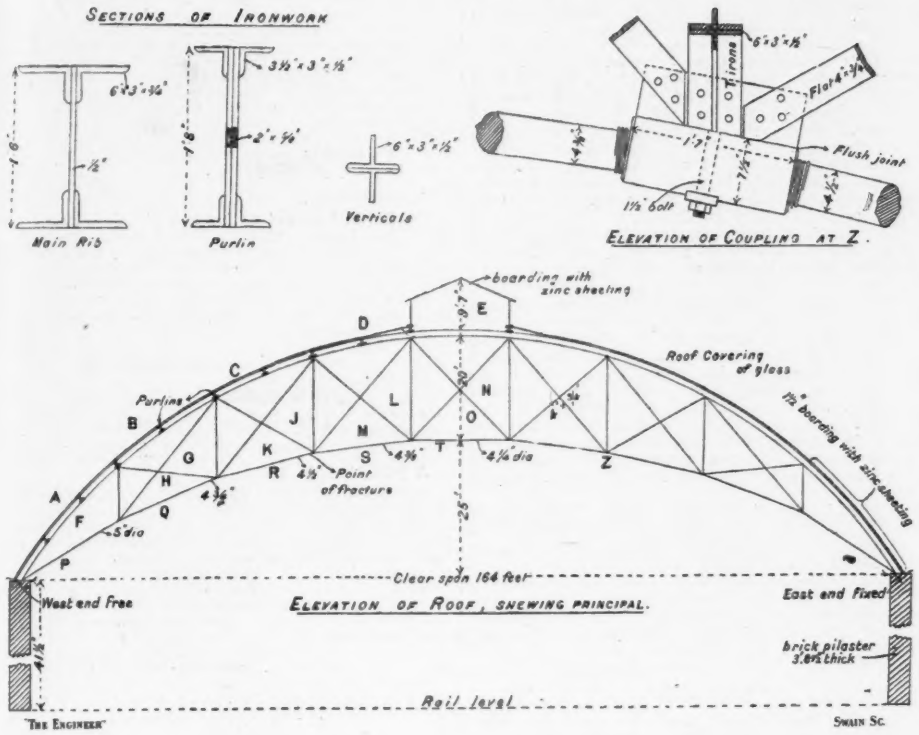
The most noteworthy feature in the evidence of Sir John Wolfe Barry refers to the conditions least likely to put on a heavy stress.

In the most ordinary conditions of wind, this particular rod must have been exposed to very high strains indeed on the part that was adhering, and it must be remembered that there was a gale of wind, which was quite remarkable, within ten days of this accident. It is such a large flaw that I should hardly think it could at first have been so bad as it turned out to be, but it is very difficult to form an opinion after a flaw has been extending for some years, because you get some discoloration from steam or moisture. It was more likely to have grown from the centre outwards. I think there can be no doubt that originally the worst place was in the centre.

Sir Benjamin Baker's evidence we give almost in full:—

I watched the erection of the Charing Cross roof as a young engineer interested in ironwork and stresses, and I made calcula-

tions of the stresses. At the time I was designing a contained arch roof for the Victoria Station, not the one which is now standing, but one that was contemplated at that time with a very much larger span. I was aware then that the Charing Cross roof was calculated for a load of 40 lb. to the square foot, which was the basis for calculation taken by architects, I daresay fifty years before, in dealing with timber roofs. This figure included wind, snow, and the weight of the structure. The round figure of 40 lb. was first fixed by Telford nearly a hundred years ago. I was aware that with the estimated load of 40 lb. to the square foot, including the weight of the structure, the stresses, under that occasional and exceptional load, would fall within the limit of elasticity of the iron—that is, at the cost of no permanent deformation from stretching. That would not be good enough according to present practice, but in those days it was considered that, provided you did not have permanent deformation, the application of such a load as 40 lb. to the square foot would be the sort of thing that would happen once perhaps in twenty years. It is different now. If you have ironwork subject to very rapid and repeated application of this load, of course, the thing would go to pieces under stress of this intensity in a few days. The Charing Cross roof was modelled in every respect upon the lines of the Birmingham roof, which three or four years previously had been submitted to the criticism of all the leading members of the profession at the Institution of Civil Engineers There was not a suggestion in the discussion that there was anything wrong about the design either as regards principals or intensity of stress. It was known perfectly well that a stress of nine tons per square inch might come upon the tie bars in a hurricane, or something equivalent to that. I do not think it ever has. In fact, I am certain it never has, or the walls would have been blown down. I might say, while on the subject of stresses, that the old Hammersmith Bridge, when the University Boat Race was on, was crowded with thousands of the public, and when they were on it the stress on the welded links of the suspension bridge was between eight and nine tons. Those links were all of iron, and they had welded ends. When that bridge was pulled down I bought a quantity of the chain work to use for temporary work on the Forth Bridge, so I had a good opportunity of seeing what the links were like after being in use forty or fifty years. Although they were subjected to that high stress they had not in the least deteriorated as regards the quality of the metal. As to the quality of the metal, there is nothing in this to account for the failure of the tie-bar. I was consulted by telephone when the accident happened, and I was on the spot within about 20 minutes, I suppose. The fall of



the roof was due to the fracture of a tie-bar, and that fracture arose from an invisible flaw which existed in the bar from the beginning. I saw the two ends of the broken tie-rod. They showed the characteristic fracture of a welded bar which had had what is technically known as a pocket in the weld. I have seen hundreds of broken welded bars, and you can easily understand that when a flaw is in a bar, and the bar has passed investigation, it follows that the flaw must be invisible—that is, that it is in the centre of the bar. In making a scarf weld, such as this was, you have to be very careful to heat the iron to the proper heat, and not to overheat it, and then you have to get it in contact and hammer at it before the atmosphere has had time to form a scale on the surface. Borax and certain kinds of sand are thrown over the surface in order to make a sort of glaze or slag so as to protect it from the atmosphere. That is a difficult thing to do. You must not assume that because there was one-third of the sectional area left there was one-third of the strength. Looking at the bar, I should say it would be nearer one-fifth than one-third of the strength, because the pull is not applied at the centre of gravity of the acting metal. Therefore, the stress is not spread uniformly. The size of the original pocket in the bar would amount to a circle of one and a-half inches or more in diameter, in which there was no metallic union whatever. Surrounding this pocket there would be a neutral zone of metal and dirt. Round the circumference of the bar there would be perfectly sound metallic contact. My experience is that in welded bars that is the normal condition leading to fracture. I knew Mr. Joseph Phillips very well, and I had such regard for his capacity as the most experienced ironwork man of the day that I got him associated with others as contractors for the Forth Bridge. I have not the slightest doubt in my own mind, knowing Mr. Phillips, knowing Sir John Hawkshaw, and knowing what was done in the case of the Birmingham roof, that the same course that was followed at Birmingham was followed here, and that every bar and coupling was tested hydraulically before it was put up. It would be a test of nine tons to the square inch. I have looked into Mr. Phillips' note-books, but I have failed to find anything about the testing of the Charing Cross roof. I am not astonished at that because it goes without saying that as he had done it before he would not think of mentioning it again. It is a very simple process to carry out this testing. In the case of cables the Government test is nine tons to the square inch. Judging from what was done by the same men at Birmingham, I have no doubt that every possible precaution was taken for testing the Charing Cross roof. If this rod broke. That shows that, if it had been a little bit stronger, it would have held the roof until there had been time to get wire ropes and make all safe. Therefore I should not condemn other roofs which are arches held by a single tie if they complied with that other condition. I should like to see a roof painted every two or three years so far as appearances go, but to do so would not have affected such a flaw as this in the least. It is more an aesthetic than a practical matter. This roof had not deteriorated to any material extent from rusting. The actual deterioration of this bar from rusting amounted to one-tenth of an inch on the mean diameter. After a roof had stood all the time that this had done, one would not suggest undertaking an examination for a fracture in a tie-rod—at least, you would not unless you were an impostor. If you were told to set out to examine it for that purpose you would say, "I am dealing with a fool, and so I will deal with him according to his folly." There are no signs of deterioration in the quality of metal in the bar in question. I have never known of ironwork being materially damaged by loads not exceeding the elastic limit, no matter how many years they have had to endure them. With all the defects of the design, you could make this roof safe for a few hundreds of pounds. That could be done by the use of wire hawsers between the principals, and by strengthening a little some of the other connections, but I strongly advised the Board of Directors to face the question at once of replacing the roof in their own interests, and in that of the public, who would always be suspicious of the roof after this accident. I advised the Board of Directors to put up a low roof so designed that the station could be widened without any interference. They have decided to do that, and the design is now practically finished. I have seen the stress diagrams handed in by the company's engineer, and have gone into them, and I confirm Mr. Tempest's calculations.

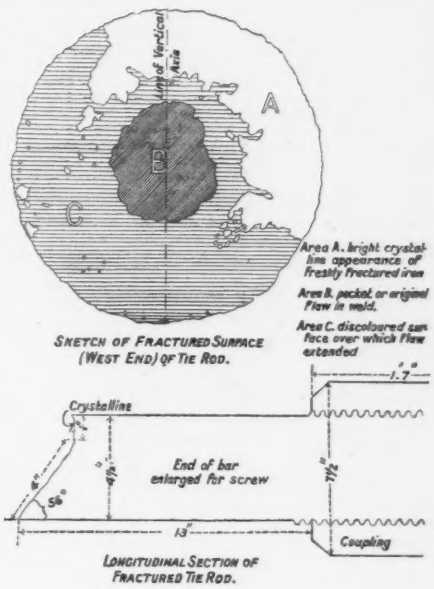
We give the following extracts from Major Pringle's conclusion. It is not necessary to reproduce his recapitulation of the facts:—

Owing to the great mass and weight of the falling *débris*, and to the necessity for safeguarding the remainder of the roof, it was not until mid-day on the 9th December that it was found possible—evidence of Inspector Chaplin—to trace the tie-rodding of the fallen principal throughout its length. It was then found to be broken at one point only, viz., in the third panel from the west, about 13in. from the third coupling joint.

The evidence proves beyond a doubt that the snapping of this particular tie-rod was the immediate cause of all that followed. The west wall, without the support of arched buttressing—as in the case of the east wall—yielded eventually to the severe thrust from the loosened bow of the first principal. But the time occupied—twelve minutes—shows that not only did the wall offer great resistance to tearing apart, but that much work had to be accomplished in breaking away from the hold exercised on the crippled principal by the lines of purlins, which were stiffened by intermediate lattice girders, and in overcoming the resistance to distortion of the main rib itself.

Turning now to the broken tie-rod, the eastern end in falling buried itself like a bayonet 2ft. in the ground. This end was unearthed on the 7th December, but the fractured surface was already rusted and corroded, and told no tale. The western end fell on the timbering of No. 2 platform, and was covered with corrugated sheeting and fallen *débris*. It was thus fortunately preserved from the effects of damp and dirt. I saw it within a few minutes of the time it was uncovered on the 9th December. The surface of the fracture was then as clean and fresh as could be desired. The appearance was typical of a fracture at a badly formed weld. From the sketches, Plate II., attached, it will be seen that approximately two-thirds of the line of fracture is at an angle of about 56 deg. with the axis of the bar, whilst the uppermost third is vertical. The surface of the fracture may be divided for the purposes of description into three parts, *vide* sketch. A belt A about an inch in width, along the vertical line of fracture, extends round the upper and northern half of the circumference of the bar; over this area the fracture had the bright crystalline appearance of iron suddenly torn apart. In the centre of the bar can be seen a flaw or pocket B with a smooth fire-skin surface, surrounded by fragments of dark coloured ash; this area is roughly circular in shape with a diameter of 1¼in. to 2in. The third portion C, mainly consisting of a belt 1½in. to 2in. in width round the lower and southern half of the circumference, was generally discoloured and corroded, with a spongy appearance common in ill-formed welds, but here and there small spots and pin-points, especially round the circumference, of clear crystalline appearance, showed signs of freshly fractured metal.

As set forth in the evidence given by Sir John Wolfe Barry, Sir Benjamin Baker, and Mr. Kirkaldy, there can be no doubt that the fracture occurred at a weld in the bar; that the core of the bar B had never united, and had never possessed any value to resist tension; that the surfaces of the area C had united, probably indifferently, except in the immediate neighbourhood of the circumference; and that the flaw, which originated in central pocket B, had gradually extended outwards over the area C under



the severe tensional stress to which—owing to the want of union in the centre—the bar had been so long subjected. The isolated bright spots and specks over the area C show that immediately before the bar snapped there was good metallic contact at these various points, as well as over the whole area A.

The total area of metal which was doing work in resisting tension at the moment when the bar broke may be roughly estimated at about one-third of the whole area, or from 5 to 6 square inches The total calculated stress—see table of stresses in appendix—in tension was 81·5 tons, or from 13 to 16 tons per square inch of available metal. Taking into consideration the excentric position of the bulk of the available area A, it will be admitted that so high a stress would be certain to cause rupture the moment the thread-like points of contact in the area C parted.

The normal stress in tension, due to weight of roof only, on this bar was about 61·5 tons. The additional stress brought to bear by weight of staging, &c., necessary for repair work was thus 20 tons, or nearly 30 per cent. more. The bar was subjected to this greatly enhanced stress for three weeks continuously before it failed, and prior to the middle of November had for four months been undergoing a stress 15 to 20 per cent. greater than would be due to weight of roof only. It is clear, therefore, I think, that the immediate cause of failure was the additional weight necessarily imposed on the principal in connection with the repair work, and it is reasonable to suppose that the failure would not have occurred at the moment it did if the tie-bar had been subjected to stress from weight of roof only. It is equally clear that the weight of staging, &c., merely accelerated the failure, which, judging from the appearance of the fracture, was bound to occur at a comparatively early date. That the flaw was growing is plain from the fact that the bar successfully withstood equally high stress imposed for a long period in the year 1898, when staging of similar weight was used for repainting work.

Sir John Wolfe Barry and Sir Benjamin Baker state in their evidence that it is probable, judging from the procedure taken in the case of the New-street Station roof, Birmingham—the prototype of the Charing Cross Station roof—that the tie-bars were hydraulically tested before erection with a stress of nine tons to the square inch—equal to 144 tons on this particular bar—and that every examination and test of the ironwork was made which the skill and care of engineers at that time could devise. Notwithstanding, the original bad flaw in the weld of this bar remained undetected.

Once the roof had been erected, the possibility of a serious flaw being in existence and growing in size until it caused a failure has never before been recognised. This is the first known case of a tie-bar in a contained arch breaking under a reasonable stress. It would not, I think, have occurred to any engineer to make any special examination to discover the possible existence of such a flaw. Periodical examinations would be made to determine the

extent of general repair work necessary. At such periods the visible weakening or loss of metal due to rust or corrosion could be gauged, the condition of the bolts and fastenings determined, and necessary action could be afterwards taken to clean and repaint ironwork, renew bars that were much decayed, and replace fastenings. But, as given in evidence, no practical method exists of detecting an interior flaw in a bar of this size under high tension, unless some sort of fissure in the outer surface was apparent. No apparent fissure could, I think, exist under such stress without the bar snapping immediately. The evidence of Mr. Kirkaldy, on the difficulty he experienced in his works of discovering and proving the existence of welds at both ends of these tie-bars, shows that the welding on the surface of the bars was very well executed.

Having dealt with various theories advanced, only to dismiss them, Major Pringle comes to the conclusion—

that the fall of the roof was brought about by the breaking of the tie-rod in the third panel from the west of the main principal nearest to the wind-screen. The fracture occurred at a weld, by reason of a flaw in the welding. This flaw, commencing in the heart of the bar, had gradually extended outwards. The additional weight of the temporary staging was the immediate cause of failure, but as the total stress in tension, at the time of failure, on the whole sectional area of the bar did not exceed 5·13 tons per square inch, I find that, for the necessary purposes of repair, such a stress was not in any way unreasonable, and could not be anticipated to cause danger of failure. Lastly, I do not consider that any reasonable precautions were neglected by the engineer or his staff in charge of the roof, or that it was possible by any practicable method to have discovered the flaw in the tie-bar.

The particular lessons to be learnt from this sad accident are as follows:—

(1) That in old iron roofs of similar design, more especially where welded bars of any size have been used, there is danger to be guarded against of concealed flaws, which may grow in size under continued tensional stress, although in itself that stress may not be exceptional.

(2) That unless additional security be afforded by the duplication or strengthening of the main tensional members there is possible risk of failure.

(3) That where such risk of failure exists, it is necessary to consider whether the walls supporting the roof are in themselves sufficiently strong to resist the thrust which such failure will bring on them, and if not to strengthen them.

As regards Charing Cross, the company have decided to remove the whole of the old station roof, and to replace it by one of the ridge and furrow type, on a lower level, with intermediate supports on the platforms. This work is proceeding, and in the meantime steps have been taken to relieve the tension on the tie-bars of all the remaining principals by taking up some of the strain with wire hawsers.

Before closing this report, I wish to draw attention to the work carried out by the engineering staff of the railway during the days immediately following the collapse of the roof. The falling ironwork struck and broke the tie-bar of the second panel from the east wall of the second main principal, and caused the tie-rodding to break away from the first and second coupling joints. The three eastern panels of this truss were thus left unsupported by ties. The western wall was also forced out of the vertical by the thrust developed by this principal, which was left standing. The condition of affairs was highly dangerous, and a further collapse of the roof might have occurred at any moment. Wire hawsers were fixed to the feet of the second, third, and fourth principals, and the tension relieved by taking the strain with crabs. A raker was fixed against the west wall, and all the glass stripped off the roof between the second and third principals. Heavily strutted wooden towers were eventually erected to take the weight of the second principal. These works were carried out by night and day, under very considerable risk to life and limb, by the engineering staff of the railway. Their efforts, which had the happy result of rendering the remainder of the roof safe, call for special mention.

SOUTH AFRICAN NOTES.

(By our own Correspondent.)

JOHANNESBURG, 21st May, 1906.

IT is now history how, after a test case appeal by the New Kleinfontein Gold Mining Company to the Supreme Court, endeavouring to prevent the posting up in the Chinese compound of the celebrated repatriation invitation, the judges decided in favour of the legality of the step, and the notices were duly affixed on the 10th inst. It is understood that up to date not more than three applications have been received, and it appears as if the Chinese labourers were content to remain and finish their contracts. Some weeks must naturally elapse before the sense of security can be restored, and trade and business are still in a stagnant condition. Gradually, no doubt, as it comes to be seen that the labour supply of the mines is not likely to suffer from the act which was so loudly protested against, the Rand community will wake up to the fact that things are not so black as they appear, and that the future is, in fact, full of promise. The Kaffir labour supply is, as is usual at this season of the year, on the up grade—that is to say, the recruiting can more than keep pace with the regular wastage.

Apart from the labour question, the mining outlook is quite bright. The gold output of the Transvaal for the month of April was declared by the Chamber of Mines at 439,243 fine oz., valued at £1,865,785. This shows a decrease of 4480 oz., of value £19,030, in comparison with the record March return, but the rate of working actually shows an increase when the relative number of working days in each month are considered. The Chinese mines, it is calculated, contributed about 35 per cent. of the output, and the significance of "repatriation" can be noticed. The total diamond output is not yet published, but the record of the largest producer, the Premier mine, is available. The output from this mine in April showed a very large increase, as will be seen from the following comparative figures:—Yield for January, 1906, 39,981 carats, value £49,976; February, 45,277 carats, value £67,915; March, 71,084 carats, value £131,505; April, 89,600 carats, value £179,200. In this four months' period the yield per load has increased from 0·27 carat to 0·35 carat, while the value per carat has improved from 25s. to 40s. In April, the first output of tin from the Transvaal was declared, this being mined by the South African Land and Exploration Company—"Sallies"—at Vlaklaagte, in the Bushveld north of Pretoria. On this property the hard and more compact rock is being reduced by rock-breakers and stamp battery, while the more weathered rock and the "griesen" are powdered in a Krupp ball mill, instead of by stamps. The further treatment plant includes grinding pans, Hartz jigs, and Wilfley tables. The total tonnage of ore treated was 687, from which 16·8 tons of tin oxide were won. The cost of production was two guineas per ton, but this includes development and other charges, the actual cost of mining and dressing per ton of ore being about 32s. Cheaper working is confidently anticipated, but at the present high price of tin a handsome profit is being made. Other tin mines in the same district will not be long in reaching the producing stage, and the hopes of a prosperous tin industry seem likely to be realised. It appears from the most recent information that the mining of tin is not likely to be confined to the Bushveld area, a very satisfactory discovery of cassiterite having been made within the last month at Pietpotgietersrust, in the Waterburg district. The work done up to the present has not been sufficient to prove the connection or the permanance of the rich patches of ore discovered.

The working of the gold mines of the Rand under the system of centralisation which was started in the various blocks under the same financial controls on the resumption of mining operations after the war appears now to be a policy likely to be generally reversed. It was initiated to endeavour to secure more economical working, to simplify administration, and to check waste. It has been violently attacked, the chief argument against the system being that it was calculated to, and, in fact, did, rob the mine manager of both initiative and incentive to improve on results already obtained. The great facts against the system are that it has not achieved the ends hoped for; working costs are but little lower, and the grade of ore mined has reduced rather than gone up.

The group of mines under the Albu control has been the first to abandon the centralisation policy, and the Messrs. G. A. and H. S. Denny have severed their connection with this mining house, and are about to start as consulting engineers in London. These gentlemen have been intimately connected with mining in the Transvaal for the past ten years, and have been always in the front in dealing with economic questions relating to the mining, metallurgical, and mechanical engineering departments for the recovery of gold, and their presence will be greatly missed in the various technical societies of the Rand, where the stimulus of their many papers and suggestions has always made for progress. There has been no public recantation on the part of the Messrs. Albu of their faith in the policy they have just departed from; but, though other immediate reasons probably account for the breaking up of the old association, the centralised general management system is now relinquished.

The general manager of the Central South African Railways has recently issued his report for the year 1905. This interesting compilation shows clearly that the results obtained in the past year are in marked advance of those previously obtained. Compared with the previous year there has been an increase of gross earnings amounting to £776,840, accompanied by a decrease in working expenses of £67,220. The surplus of earnings over working expenditure amounted to the sum of £2,546,691, there being an increase in this respect of £844,060. Regarded per train mile, there has been a reduction of expenditure of 0·9d., while there has been an increase in the earnings of 2s. 4·4d. With an increased average open mileage, the train mileage has been reduced, owing to the employment of more powerful engines. The number of passengers carried and the tonnage of goods hauled are both largely increased, as also the revenues derived therefrom. The railways of the Coast Administrations, of course, profited largely in the revival. For the conveyance of traffic to and from the Transvaal and Orange River Colony the Cape Government Railways received £1,157,040, or 28·5 of their total railway revenue, while the Natal Government system received £1,085,941, or 52·9 of its total revenue. Mr. T. R. Price estimates that the £281,801, the share falling to the Portuguese Railway Administration, represents nearly the whole of its railway revenue, and he alludes in his report to this very practical testimony of the way the material interests of the Coast Colonies are vitally concerned in the development and progress of the Interior. Regarding new construction, it is stated that when all the projected lines are constructed the approximate length of the C.S.A.R. system will be 2749¾ miles, and that by the end of the present year the railway mileage opened and in working order will be more than double that existing in the two Colonies in the year 1898.

The financial aspect of the Central South African Railway report for 1905, while regarded by everybody as testifying to the efficiency and the economy with which our railways are worked, is still open to the criticisms of many, on the ground that a State railway administration is not justified in making such a huge yearly profit as 2½ millions sterling. This revenue, under the present estimates, is naturally required to meet administrative requirements, but there is a very general feeling that, in the future, railway rates should be reduced, and that the needs of Government should be ministered to by the imposition of some more fair and equitable tax. A graduated income tax, to be levied on all incomes derived from South African sources, has been proposed. When responsible government is an accomplished fact there will be more heard of this question.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Ironworkers' Wages.

Ironmasters are awaiting with much expectation the circulation by the Wages Board of the details of the new sliding scale which has just been arranged by the Joint Standing Committee of masters and men. The foundation of the new scale is the adoption by the masters of the men's recent new propositions, the employers really having no serious fault to find with them. These proposals greatly widen the area of firms from which ascertainments of prices for wages purposes will in future be taken, and necessarily, therefore, the classes of iron upon which the average is struck. They re-affirm the old principle that the Staffordshire and Midland puddlers are entitled to 6d. per ton over the North, in lieu of Northern extras. The basis of the new scale is fixed at 2s. premium, over 1s. 6d. under the old scale. Thus the men secure a material rise in the basis of the scale, and it is a circumstance which is giving rise to some comment amongst the ironmasters that the new premium gives the exact wages now being paid. In some circles this is considered too high, but there is no doubt that it will be maintained.

Improving Iron Trade.

The sheet iron trade is active, and the larger business arriving at the galvanisers is producing a welcome extended list of orders for black iron. As a result the mills are running more regularly, and prices are stronger. Black sheets of 24 gauge well maintained at £7 15s. to £8; 27 w.g. and 28 w.g., £8 7s. 6d. to £8 12s. 6d.; and galvanised corrugated sheets of 24 g. packed in bundles, £12 10s. to £12 12s. 6d., f.o.b. at outports.

Keeping Out Belgian Iron.

Common bars are quoted £6 10s., but in some cases are being done for less, orders changing hands at £6 5s. per ton. Belgian and German bar iron, which a few weeks ago entered seriously into competition with Staffordshire common bars owing to its low price, is now ignored, as it is possible to obtain Staffordshire material at several shillings below what the Belgian and German bars can be bought. North Staffordshire makers are much better off for orders than makers locally, and they continue to quote £7 5s. for "Crown" qualities of bars. Gas-tube strip is in moderate inquiry at £6 12s. 6d. for large and £6 15s. for small orders. Hoop iron remains at £7 15s., and nail rods £8 per ton.

Advance in Wire.

Manufacturers of iron and steel wire have advanced the price of mild steel wire 15s. per ton. German firms had already announced a rise of 10s. in wire rods and £1 in wire. For some time they have paid practically no attention to the English market, having been fully occupied in supplying the wants of their own continental markets. The way was thus thrown open to our makers to declare an advance in prices without endangering their trade, and, wisely enough, they have taken advantage of the favourable situation.

Ironmaking Materials.

Ironmaking materials still rule high. Pig iron, although having fallen considerably, has by no means shared the full reduction in finished iron, while fettling for lining the puddling furnaces at the forges is very expensive, being about 24s. per ton, as compared with 13s. 9d. before the late boom began. It seems likely that during the next six months ironmasters' resources will be considerably taxed.

New Tube Works.

There is a report that a new tube works is about to be established at Walsall by a new private company, with an initial capital of £10,000. A site for the new works has already been secured.

Bolt and Nut Trade.

Mr. Walter Harley, of Smethwick, Birmingham, has been elected the new chairman of the South Staffordshire Nut and Bolt Trade Wages Board.

Canalisation.

A conference of local authorities and chambers of commerce of the Midland Counties, convened by the Birmingham Chamber, will be held early next month to consider the canal question. The object is to determine if possible upon common evidence establishing one or two main principles before the Royal Commission. The principal seaports connected with Midland trade will be invited to co-operate. This week Mr. Morton, of the firm of Fellows, Morton and Clayton, canal carriers, Birmingham, in his evidence before the Commission, advocated State control, and estimated approximately that instead of the total through traffic amounting, as stated in the Board of Trade returns relating to canals, to 22¼ million tons, it was actually less than 8 millions. He pointed out how the department had, by a faulty system of statistics, counted the same traffic five times over. The Birmingham canal was as much under railway control as if railway owned. That policy had resulted in a great discouragement of through traffic. Steam haulage would reduce the cost of conveyance to a tenth of a penny per mile per ton.

Copper and Tin.

The high price of tin has seriously affected some of the Birmingham hardware trades, and some manufacturers find it cheaper to obtain supplies of raw material by melting down old stock than to manufacture in metal in the ordinary way. The dearness of metals has also caused discounts of manufactured goods to be revised. This has caused friction among factors and merchants, who allege that they cannot obtain the additional money from their customers.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, June 21st.

A Quiet Market.

IF a scientific term is permissible in a business connection the Manchester market for pig iron might be described as in a state of "suspended animation." It is true there is a very ordinary business passing, but inquiries for forward delivery are by no means numerous, and merchants do not appear to be in a speculative mood at all. Indeed, the outlook is somewhat uncertain. The fact of the strong statistical position, coupled with heavy shipments both from the East and West Coasts, must be considered in future calculations, but we were assured on the Manchester Iron 'Change on Tuesday, that more than one firm would, with *bonâ fide* offers, be prepared to sell up to the end of the year at present prices. To some extent here the position is accentuated by after-holiday effects, the market not yet having recovered its wonted elasticity. As it is, there is again no change to record in prices. Forge iron also appears to be in small demand at late rates.

Finished Iron.

There is a steady business passing, and merchants are still well off for orders.

Steel.

Billets are in request, but plates are somewhat weaker. Most agents report a good all-round demand, however.

Manufactured Copper.

The decline in the raw article has at length caused a move in manufactured material. Sheets have been reduced £3 per ton, but there is no change to be reported in copper or brass tubes.

Quotations.

Pig iron: Lancashire No. 3 foundry, 61s.; Lincolnshire, 56s. 6d.; Derbyshire, 58s. 6d.; Staffordshire, 55s.; Middlesbrough, open brands, 59s. 4d. to 59s. 8d. Scotch: Gartsherrie, 64s.; Glengarnock, 62s.; Eglinton, 61s. 6d. to 62s.; Dalmellington, 61s., delivered Manchester. West Coast hematite, 65s. f.o.t.; East Coast ditto, 67s. f.o.t. Scotch, delivered Heysham: Gartsherrie, 62s.; Glengarnock, 60s.; Eglinton, 59s. 6d. to 60s.; Dalmellington, 59s. Delivered Preston: Gartsherrie, 63s.; Glengarnock, 61s.; Eglinton, 61s.; Dalmellington, 60s. Finished iron: Bars, £7 5s.; hoops, £7 17s. 6d.; sheets, £8 7s. 6d. to £8 12s. 6d. Steel: Bars, £7 5s.; hoops, £7 15s.; boiler plates, official, £8 12s. 6d.; plates for tank, girder, and bridge work, £7 7s. 6d. to £7 12s. 6d.; English billets, £5 7s. 6d. to £5 15s.; sheets, £8 17s. 6d. Copper: Sheets, £96 per ton; seamless copper tubes, 11⅜d.; brazed ditto, 11½d.; seamless brass tubes, 9½d.; condenser, 10½d.; brazed brass tubes, 10½d. to 10⅝d.; rolled brass, 8⅞d. to 9d.; brass wire, 8⅝d. to 9d. per lb. Sheet lead is steady and unchanged, at £19 15s. per ton.

The Coal Trade.

As can be well imagined, the brilliant weather has practically stopped the house coal trade, and as the demand for shipping account is still quiet, short time at the pits is now becoming general. This causes a decline in the quantity of slack produced, and as the demand is strong, it is stated that a premium on official prices is being paid in some cases. Manufacturing coal is in request. Quotations are still somewhat nominal as follows:—Best house coal, 13s. to 14s.; seconds, 12s. to 12s. 6d.; common, 9s. to 10s.; best engine fuel, 8s. 2d. to 8s. 11d.; steam and forge coal, best, 8s. 8d. to 9s. 3d.; best slack, 7s. to 7s. 6d.; medium,

6s. 5d. to 7s. 2d.; common, 5s. 5d. to 6s. 2d. at the pit. Screened coal, 10s. to 10s. 3d.; unscreened, 9s. 6d. to 9s. 9d., delivered Manchester Ship Canal.

Labour Position and Prospects.

Reports show that in the engineering trades the percentage of unemployed is lower than in any month since June, 1900. In the Manchester and Liverpool district it is 2·5, as compared with 5·7 at the corresponding period of last year. In Manchester some overtime has been worked by engineers and ironfounders. In Oldham, Bolton, Blackburn, and Burnley a great deal of overtime has been worked in nearly all sections. Unfortunately, the ironmoulders have refused the advance offered by the masters in the Colne district, and have come out on strike. There is also trouble amongst the brassfounders in another part of Lancashire. At Accrington Messrs. Howard and Bullough have advanced the wages of the men without solicitation, owing to the good position of the textile machine-making industry.

BARROW-IN-FURNESS, June 21st.

Hematites.

A brisk business is being done in hematite pig iron, although the outlook at the moment is not so satisfactory as it has been. There is, however, reason to believe that if the demand falls off in one direction it will improve in another, and anticipations are indulged in by those who are in the best position to form a judgment of the prospects of the future that a fairly steady trade will be maintained during the rest of the season. Big deliveries of iron are being made as well by sea as by rail, and these are likely to be maintained for some time to come. Warrant stocks have been reduced during the week by 470 tons, and now stand at 75,271 tons, and are fairly well held. There are 38 furnaces in blast in the district, and it is expected soon that at any rate one furnace will be put on charcoal iron, for which the demand is steady. Ferro-manganese is being largely bought in this district at present. Forge and foundry pig is quiet. Makers still quote 67s. for parcels of mixed Bessemer numbers nominal, and warrant iron is at 64s. 10½d. net cash sellers, buyers 3d. less. Scrap iron is selling freely and local stocks have been largely diminished of late. Iron ore is brisk at 15s. net at mines for good average native sorts, and Spanish ores are selling at 19s. 6d. net at West Coast ports, and are being largely imported. Harrison, Ainslie and Co. report the discovery of large deposits of iron ore on its Lindal Moor royalties. The firm's explorations have been conducted in two different parts of its royalty, and in both cases they have resulted in finds of what promise to be large beds of raw material of good quality.

Steel.

The plate mills at Barrow, which have been working night and day since last September, have only been working half time this week, a sign either of the falling off of orders, or of waiting for specifications. The fact is the demand is weaker than it has been, but it is expected to improve. Prices remain steady at £7 7s. 6d. for ship plates, £7 17s. 6d. for boiler plates, and £7 for angles net cash. Very few angles are produced in this district. The trade doing in steel rails is steady, and the mills are working night and day on orders, mostly on colonial account. Prices are steady at £6 7s. 6d. per ton not f.o.b. It is believed much more business would be done if prices were a little easier. Merchant steel quiet.

Shipbuilding and Engineering.

The only new item this week in the shipbuilding trade is the launch at Barrow on Wednesday of a floating dock for the British Admiralty, for submarine use at Hasler Creek, Portsmouth. She is 250ft. long and 50ft. 6½in. broad, with side walls 200ft. long, and with a height of side walls of 28ft. She is 700 tons weight, and will lift 500 tons 25ft. to 26ft. in one hour. No new shipbuilding orders are reported, and work in the Barrow yard is getting scarce. Engineers are, however, well employed in most departments.

Shipping and Coal.

The exports of iron and steel from West Coast ports last week totalled at 14,568 tons, showing an increase of 3069 tons over the corresponding week of last year. The total exports this year have reached 352,901 tons, being a decrease of 41,454 tons on the corresponding period of last year. Coal and coke are firm at steady prices, and are in large demand on manufacturing and shipping account.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Trade Situation.

THE influence of the recent holidays has soon been shaken off, and in all departments the ordinary course of business is being pursued with a vigour which has been all too lacking during recent years. It is refreshing to chat with manufacturers and hear that, on the whole, they are well satisfied with trade as it is. There are certainly no complaints, except in the lighter trades, where the high cost of raw material continues to be a serious factor in the situation. In the iron, steel, and coal trades the general opinion seems to be that the state of affairs will gradually improve, though we shall probably see no boom like that of last autumn. And there is no desire that such a boom should take place. That of last year fulfilled its purpose in that it forcibly stimulated business and brought in a rush of work, the effect of which is yet important. Now the wish is that the trade position will open up gradually and steadily, without any undue booming in any direction, so that prices may maintain a level advantageous to all parties. Nothing so surely upsets legitimate industry as wild fluctuations in the cost of raw material.

The Coal Trade.

There is little change in the position of the coal trade from last week, but market tendencies and influences which were then merely mapping out their direction have become more pronounced. House coal, for instance, is not talked about, and it seems almost absurd to mention this department with the thermometer at its present level. One curious fact, however, is noticeable. The weakness in this section is confined chiefly to the best qualities, and even here trade, for the time of year, is correspondingly good, for many far-seeing ones are taking advantage of the range of prices now to lay in supplies to carry them through the winter. Prices are rather undecided, and it is not too easy to quote, for there are rumours of severe underselling by some of the local colliers. There seems no pressure of second-class qualities of house fuel on the market, and in this connection it is freely reported that some colliers are going to the extent of offering the second rate seams to the works for manufacturing puposes, thus suffering a severe drop in prices. The explanation, however, is that colliery owners are merely looking ahead, and they do not intend to ruin their contract rates for winter business by accepting ridiculously low prices now. There is no doubt, also, that a heavy tonnage of medium grade house coal is being sent away unscreened for gas carbonisation purposes.

Continued Demand for Steam.

The shipping demand for all qualities of hard fuel is remarkably strong, and a very large tonnage is going to the Humber shipping ports both by rail and canal. The exact figures are not yet available, but it is not without interest to note that the shipments from Hull to foreign ports for the week ended June 12th showed an increase of more than 27,000 tons over the corresponding period in the previous year, the figures this year being nearly doubled, while from Grimsby the advance was more than 5000 tons. In addition, the steady development of the steam fishing industry from the Humber ports has opened up quite a new and important market, for the requirements of the long distance trawlers add up to a very considerable total. The works are taking a good quantity of manufacturing fuel, but after all it is the shipping business which tells most just now, and so long as this holds up at all well, the activity in the coal trade will continue. Most of the pits were closed for the miners' demonstration on Monday, and in many instances Tuesday was regarded as a "play" day, so the output during this week has been substantially lessened, and stocks have been correspondingly depleted.

Gas Coal Contracts.

The arrangement of gas coal contracts for the twelve-months commencing in July has now been practically completed. There have been some curious up-and-down movements. West and South Yorkshire gas coal producers early found themselves in a very advantageous position, for a good foreign demand at Newcastle resulted in prices being so advanced there that the large metropolitan companies—the Gas Light and Coke Company, the South Metropolitan Company, and the South Suburban Company—placed largely-increased contracts in this district at prices fully 6d. and 9d. per ton over the rates ruling a year ago. The Derbyshire and Nottingham people were not so fortunate, for, in several cases, contracts made twelve months ago carried with them the option of renewing for another year at the same rate, and this clause the consuming companies were not slow to take advantage of. New business, however, at one time commanded a 6d. per ton advance, which gradually fell away to nothing, while now the improvement is about 3d. per ton. Only a few small contracts are now outstanding, but the rather important one of Sheffield will not be negotiated for another six weeks or so.

The Heavy Trades.

As mentioned in the opening paragraph, the condition of the heavy trades in the city and district is in every way eminently satisfactory. Work comes in in fair volume, quite sufficient to keep the works steadily going, to say nothing of the large bookings ahead, which have sustained business all through the year. No new orders of note have been placed, but the small bookings make up a satisfactory aggregate. There is no change in the official quotations for raw material, but a harder tone marks prices, which may generally be quoted as follows:—Lincolnshire forge, 52s.; ditto foundry, 54s. 6d.; ditto basic, 54s. 6d.; Derbyshire forge, 52s. 6d.; and foundry 55s. 6d. Hematites are rather easier, East Coast being 74s. and West Coast 75s., in both cases less 2½ per cent.

Cammell Laird and Co.'s Expansion.

The directors of Messrs. Cammell Laird and Co., at the special meeting this week, did not take their shareholders into their confidence regarding the purposes to which the additional capital they propose to raise shall be applied. It was explained, however, that the completion of the new armour-plate mill—particulars of which have already been given in THE ENGINEER—and their new shell-making plant would fully absorb the remains of their last debenture issue, and they now asked the shareholders' consent to the issue of debentures to the extent of a million sterling, but, said Mr. Laird, it was undersirable that the purposes and extensions to which this was to be applied and the methods of raising money should yet be stated. The shareholders expressed continued confidence in the Board, and passed the resolution unanimously.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

THE fact that the buying at present in this branch is slow is not disquieting to the makers, for they are well situated as regards orders, and never were they called upon to deliver such large quantities of iron. The shipments of pig iron from the Cleveland district are this month larger than they have been reported in any previous month, exceeding even the unprecedented figures of last month. Producers just now are practically independent of buyers, as they are so well sold ahead, and what they have will tide them over the usually quiet month of July. Before they are short, buying will be on again for autumn deliveries. As a rule, they have no iron in stock, and iron is being taken out of the public warrant stores at a very rapid rate, faster, indeed, than it accumulated, so that June will probably show a decrease of 40,000 tons. No. 3 Cleveland G.M.B. pig iron has mostly been sold this week for early f.o.b. delivery at 50s. 6d. per ton, but neither makers nor second hands would accept as low a figure for forward, because better prices are expected for August and beyond. That, indeed, is the usual experience. No. 1 is at 52s.; No. 4 foundry at 49s. 9d.; No. 4 forge at 49s.; mottled at 48s. 6d.; and white at 48s.; all for early delivery. The lower qualities are thus relatively cheaper than No. 3, as also are Cleveland warrants, these latter having been quoted as low as 49s. 11d. this week, the closing figure on Wednesday being 50s. 1½d. cash.

The Hematite Iron Trade.

In this district business in this branch is dull, and prices rather weak, with competition somewhat keen. It is true that quotations are relatively higher than they are for Cleveland pig iron, mixed numbers of East Coast hematite pig iron being about 15s. per ton higher than No. 3 Cleveland pig iron, the ordinary difference being 10s., but it is questionable whether the producers are doing as well as those making Cleveland iron. The materials used by the hematite producers are dearer; the Rubio ore is at 19s. 9d. per ton delivered c.i.f. Tees, and this signifies that nearly two-thirds of the price realised for the pig iron goes to pay for the ore used. There is no doubt that ore is much too high at present. Moreover, coke is becoming dearer; in fact, most of the sellers are quoting 6d. per ton more than in the early part of the month, or 17s. for medium qualities delivered at the Middlebrough furnaces, against 16s. 6d., and, what is more, they are realising the higher rate, as there is no overplus of coke now. While cost increases the value of the iron is declining, and mixed numbers have been readily forthcoming at 65s. 9d. per ton this week. But consumers hold off for still lower rates. Merchants have offered to buy heavily for forward delivery at 65s., but makers are not prepared to accept that.

Exports of Pig Iron.

Last month's shipments of pig iron from the Cleveland district were the largest on record for any month, but the current month's exports are larger still, and there is reason to believe that they will continue good for some time, and thus tide the makers over what is usually a dull period of the year. Never have ironmasters in this district had so active a time as the current half-year has been, and it is all the more satisfactory as the chief buyers have been countries which it was thought would never more need to go outside their own confines for their supplies of pig iron. Germany with a make increased to nearly twelve million tons of pig iron has, nevertheless, this year suffered from a shortage, and has bought Cleveland iron as freely as at any period. The total shipments of pig iron from Cleveland this month up to 20th reached 92,655 tons, as compared with 86,495 tons last month; 59,884 tons in June last year, and 50,846 tons in June, 1904, all to 20th.

Manufactured Iron and Steel.

What producers in these branches complain of is the absence of fresh orders, but as yet that does not inconvenience them or lead them to reduce their quotations, because they are well supplied with contracts. There have been very heavy shipments this year, especially of rails, sheets, and bars. The price of heavy steel rails is strong at £6 7s. 6d. per ton, f.o.b., but for chairs and sleepers the quotations are not so steady, as they do not feel the improvement which is so noticeable a feature in the rail trade. Sellers are glad to get £3 15s. for cast iron chairs and £6 17s. 6d. for steel sleepers, both f.o.b. There is more activity in the galvanised sheet trade, and the price for both steel and iron galvanised sheets has been advanced to £12 12s. 6d. per ton, 24 gauge in bundles, and f.o.b. These are going freely to India, Japan, and South Africa. Steel ship plates are steady at £7, and iron ship plates at £7 5s., both less 2½ per cent., f.o.t. Steel ship angles are firm at £6 12s. 6d., steel bars at £7, and iron bars at £7 5s., all less 2½ per cent., f.o.t.

An Angle Makers' Combination.

Last year the plate makers of the North of England and Scotland entered into an arrangement which was designed to prevent undercutting in prices. It was provided that the Scotch makers should deal with the orders of Scotch consumers, and the North of England producers should supply the wants of the shipyards on the North-East Coast—in fact, that they would not invade each other's own immediate districts. Previously, the only parties who reaped any benefit from the competition were the railway companies. The arrangement has worked well, and now an endeavour is being made to organise a similar combination in the angle trade. An effort was made when the plate combination was arranged, but it fell through. Now, however, the proposal is being revived, and with some expectation of success. A conference was held at Newcastle a few days ago, and a further conference is shortly to take place in London, with the view of making the organisation a national one.

Shipbuilding and Engineering.

The situation is not favourable, for while there is yet plenty of work at the shipyards, orders are not coming in at all well. There is nothing to encourage shipowners to add to their fleets; indeed, there is almost everything to deter them. Freights have been very disappointing, the homeward rates being specially unsatisfactory, and outward rates are declining also, coal freights having dropped rather quickly. Naturally, in these circumstances, shipowners look upon the heavy output of new shipping from the yards with no little apprehension, and it is expected that before long it will become necessary to lay up some of the steamers; certainly, freights do not allow of the older vessels being run at a profit. Owners cannot afford to pay the present rates asked by the shipbuilders, and these, it is generally believed, will have to come down.

Dispute at Ormesby Works.

The dispute between Messrs. Cochrane and Co., Ormesby Ironworks, Middlesbrough, which has been in progress for several weeks, and involves the stoppage of 1200 men, has not yet been settled. The pipemakers on piecework offer to accept a reduction of 5 per cent. in the rate of pay on the understanding that, owing to the increased output possible by means of the improved machinery, this should not mean an actual reduction in the wages received. The firm is considering this offer.

The New High-level Bridge at Newcastle.

This is to be opened by the King on the 10th July, when he journeys north to take part in the opening of the completed Armstrong College and the Royal Victoria Infirmary.

North-Eastern Railway Wages.

A meeting of the delegates of the men employed by the North-Eastern Railway Company over the whole system was held at Darlington on Sunday to consider the results of the conferences held at York and Newcastle on the subject of working arrangements, of hours, and of pay. Mr. R. Bell, the general secretary of the A.S.R.S., issued a report, and it was decided to adjourn the conference for three weeks to give the branches an opportunity of considering the acceptance or rejection of the terms. Mr. Bell unhesitatingly advises the men to accept the terms as a settlement of the present movement, and hopes that in the near future they may induce the directors and officials to form a conciliation board at which the men's grievances may in future be considered. Mr. Bell speaks highly of the manner in which the delegates were received by Mr. Butterworth and his colleagues. The men's representatives, he says, were treated with the greatest courtesy, patience, and fairness during the eleven days over which the conference lasted.

Coal and Coke.

The market continues to improve, and exports are helped forward by the low freights. The prospects are good, and lower prices are not looked for. The output of steam and gas coals is pretty nearly up to the full production, and sellers are very firm. Best steam is up to 10s. 6d. per ton f.o.b.; seconds to 9s. 6d.; and smalls to 6s.; while best gas is at 10s., and consumers are buying well ahead at these figures. There has been also a brisker demand for coke and a reduced production, so that there is no longer a glut, and some of the sellers have raised their price 6d. per ton, 17s. being asked and realised for medium coke delivered at the Middlesbrough furnaces, only small quantities being forthcoming at 16s. 6d. Foundry coke is at 18s. to 18s. 6d. f.o.b. The Wearmouth Colliery Company is about to sink a new shaft and to construct new quays and staiths on the river, while the River Wear Commissioners are to deepen the river so as to float vessels drawing 24ft. of water. The Weardale Steel, Coal, and Coke Company is installing at Tudhoe Works a large by-product coke oven plant.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General State of Trade.

THERE is steady employment in all the great branches of industry. While complaints are heard that new orders do not come to hand so freely as could be desired, the work at present available will keep works running for some time. The trade holidays will intervene within the next few weeks, and the expectation is that by the beginning of autumn some fresh business developments may take place.

The Warrant Market.

Business in the Glasgow pig iron warrant market has been irregular. On some days there has been considerable weakness, ascribed to bear selling; whilst in others the market has recovered. The statistical position is considered satisfactory, especially on account of the renewed large shipments from the Middlesbrough district. Business has been done in Cleveland warrants at 50s. to 50s. 2d. cash, and 50s. 2½d. to 50s. 8d. one month. Large sales of Cleveland iron are reported to have been made for shipment in autumn, and it is even rumoured that sales in some cases have taken place for delivery in the early part of next year. Scotch warrants have been at 56s. 6d. to 56s. 3d., and standard foundry pig iron 50s. 4½d. to 49s. 9d. per ton.

Hematite Pig Iron.

The market for hematite has been less buoyant, and there is a tendency to curtail the output to some extent. Merchants

quote Scotch hematite 69s. 6d. for delivery at the West of Scotland steel works, and Cumberland hematite in our market has varied from 64s. 10½d. to 64s. 9d. per ton. There are large quantities of iron to deliver under existing contracts, but the demand in the shape of new business is at the moment somewhat restricted.

Output and Stocks of Pig Iron.

Since last report one furnace has been transferred from hematite to ordinary at the Clyde Ironworks, one at Gartsherrie, and one at Eglinton, so that the number of furnaces making hematite has been reduced from forty-eight to forty-five, and those making ordinary iron increased from thirty-four to thirty-seven. The total number of furnaces in blast is eighty-eight, compared with eighty-five at this time last year. The stock of pig iron in Glasgow warrant stores shows the small decrease of 15 tons, and at the time of writing consists of 12,144 tons Scotch warrants, and 6650 standard foundry pig iron.

Foreign Inquiries for Basic Iron.

Merchants state that they have had within the last few days considerable inquiry, both on Belgian and German account, for basic pig iron. The production of this class of iron in Scotland is limited to the output of half a dozen furnaces, and it is understood that of late the whole of it has been required for the home manufacturer. Whether anything can be done to meet the foreign demand it is difficult to say.

Prices of Scotch Makers' Iron.

The prices of Scotch makers' pig iron, in some cases, show a further reduction of 6d. per ton. G.M.B., No. 1, is quoted at Glasgow 57s. 6d.; No. 3, 55s. 6d.; Monkland, No. 1, 58s.; No. 3, 56s.; Carnbroe, No. 1, 61s.; No. 3, 58s.; Clyde, No. 1, 65s.; No. 3, 60s.; Gartsherrie, No. 1, 65s. 6d.; No. 3, 60s. 6d.; Calder, No. 1, 66s.; No. 3, 61s.; Summerlee, No. 1, 68s.; No. 3, 63s.; Langloan, No. 1, 69s.; No. 3, 63s.; Coltness, No. 1, 73s.; No. 3, 62s.; Glengarnock at Ardrossan, No. 1, 66s.; No. 3, 60s.; Eglinton at Ardrossan or Troon, No. 1, 60s.; No. 3, 57s. 6d.; Dalmellington at Ayr, No. 1, 62s 6d.; No. 3, 57s. 6d.; Shotts at Leith, No. 1, 66s.; No. 3, 61s.; Carron at Grangemouth, No. 1, 67s.; No. 3 62s. per ton.

Scotch Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 6295 tons, compared with 8033 in the corresponding week of last year. There was despatched to the United States 850 tons, Canada 150, South America 200, India 130, Australia 1050, France 90, Russia 100, Germany 255, Holland 180, Belgium 20, Spain and Portugal 165, China and Japan 210, other countries 135; the coastwise shipments being 2760 tons, against 3885 in the corresponding week of last year.

Arrivals of English Iron.

The arrivals of Cleveland pig iron at Grangemouth in the past week amounted to 9105 tons, being 103 tons less than in the corresponding week, but there has been a total increase in these arrivals since the beginning of the year amounting to 20,472 tons.

Finished Iron and Steel.

There is a quiet business doing in finished iron, but the works, generally, have good employment. Most of the steel works are busy, and there is a prospect of the unprofitable competition in angles being overcome by negotiations that have been proceeding between representatives of English and Scottish manufacturers. Large deliveries of material are still taking place to the shipyards. At the same time there is a decided lack of new inquiries for future supplies of this description. It is to be hoped that this quietness may prove to be only temporary.

The Coal Trade.

The coal shipments from Glasgow are about 7000 tons less than in the preceding week, but there has been a large increase on the East Coast, so that the total shipments from Scottish ports are 29,993 tons better than in the preceding week, and 13,282 tons larger than in the corresponding week of last year. The clearances at Glasgow were 59,163 tons, compared with 67,725 in the preceding week, and 55,365 in the same week of 1905. There has been a rather better inquiry for household coal for home use, and the demand for manufacturing purposes is well maintained. The Corporation of Glasgow has fixed contracts for about 260,000 tons of coal, and decided to ask for fresh tenders for the rest of its supply, which will amount to about 500,000 tons additional. It is stated that the average price of the coal just purchased is from 3d. to 3½d. per ton above the rate paid this time last year. The Corporation of Paisley has decided to ask for fresh tenders for its coal supply, owing to an easier tendency in the market, and the possibility of being able to fix up the year's requirements somewhat below the figures already submitted.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Boom in Steam Coal.

A STRIKING scene has been presented at the chief coaling ports this week, Cardiff, Penarth, and Barry having been exceptionally busy. On Monday there were seventy steamers at the last-named port, some discharging pitwood, but the majority busy in loading coal. The great rush of work has been carried on with mechanical ease. While the docks are crowded, the line of "light" steamers coming up the Channel shows no falling off, and with favourable weather continuing the present boom seems likely to last. It is reported that one large owner has sold 70,000 tons, best, to be delivered in June and July. On Tuesday Roath Dock had, in addition to numerous vessels, five very large steamers loading, representing a deadweight capacity of over 40,000 tons. Steamers are, of course, prominent, but sailing vessels are also to be seen in this and other docks, and, though great steamers are in favour, the good old serviceable ones with light draught are continued. In the compass of one man's lifetime the sloop of a few hundred tons has been succeeded by huge steamers of a carrying capacity of 8000 tons. While the Cardiff ports have enjoyed a great deal of the boom, Swansea despatched last week 84,000 tons, of which nearly 35,000 went to France. Newport, Mon., was similarly busy, sending 84,596 tons away to foreign destinations, and nearly 11,000 tons coastwise. Port Talbot last week indicated an increase of 11,254 tons over the previous week, and a more active condition is beginning to show at Llanelly.

Latest Coal Prices.

Mid-week the report on 'Change, Cardiff, represented unabated inquiry for best and second-class Admiralty large steam. Dry coals are in demand; house coal has entered upon its summer slackness, and will continue until the autumn. Small steams are strongly held. Monmouthshire semi-bituminous shows an upward tendency. No. 3 Rhondda house coals are nominal. Closing prices, Cardiff:—Steam, best large, 15s. 9d. to 16s. 3d.; best seconds, 15s. to 15s. 6d.; seconds, 14s. 6d. to 14s. 9d.; drys, 12s. 9d. to 13s. 3d.; best washed nuts, 12s. to 12s. 6d.; seconds, 11s. 6d. to 11s. 9d.; best washed peas, 10s. 9d. to 11s.; seconds, 10s. 3d. to 10s. 6d.; very best small steam, 9s. 9d. to 10s.; best ordinaries, 9s. 3d. to 9s. 6d.; seconds, 8s. 6d. to 9s.; inferiors, 8s. to 8s. 3d. Monmouthshire semi-bituminous coal: Best large, 15s. to 15s. 3d.; best ordinaries, 14s. to 14s. 6d.; seconds, 12s. 6d. to 13s. 3d. House coals: best, 15s. 3d. to 15s. 6d.; best ordinaries, 14s. to 14s. 6d.; seconds and other sorts, 11s. to 13s. No. 3 Rhondda, 15s.; No. 2 Rhondda, 11s. to 11s. 6d. Patent fuel, 16s. to 16s. 6d.; pitwood, 21s.

The Hauliers.

There is a possibility of trouble again amongst the hauliers, and if pacific measures are not successful 5000 men will be affected. The contention on the part of the hauliers is that the coalowners are endeavouring to make it compulsory to work overtime, whereas they take the ruling of the agreement entered into to be voluntary.

Threatened Strike amongst the Anthracite Colliers.

Some of the alarmists are predicting a strike in the anthracite coalfield. It appears that a large number of non-unionists are in the district, and notices are threatened in July if they do not join the Union. Very probably they will give way before the end of the month.

Another New Colliery Undertaking.

Every now and then evidence is forthcoming that a large area of virgin coal ground exists in Wales. A new venture by the "Welsh Navigation Company" is being discussed. The scene is south of the Cambrian and naval collieries, a little way out of the anticlinal, and is expected to escape the troubled ground which has caused so many disasters. It is thought that a good area of No. 3 Rhondda will be won, and steam coals reached at 800 yards. The venture will, if successful, add largely to the coal wealth.

State of the Anthracite Coal Trade.

A moderate amount of business is being done in the district. On 'Change, Swansea, it was stated this week that the inquiry in most cases is well maintained. Large is firm; rubbly culm and duff very strong, and no signs of falling off. Latest prices are:—Large malting, 18s. to 19s.; seconds, 17s. to 18s.; big vein, 12s. 6d. to 13s.; red vein, 9s. 6d. to 9s. 9d.; cobbles, 17s. to 18s. 6d.; nuts, 18s. to 19s. 6d.; peas, 9s. 6d. to 11s. 6d.; culm, 6s.; duff, 4s. 3d. to 4s. 6d. Swansea reports steam coal at 15s. 6d. to 15s. 9d.; No. 3 Rhondda, 14s. 9d. to 15s. 3d. Patent fuel 13s. 6d. to 14s. A London company, I hear, is likely to acquire a large area of anthracite coal near Ystradgynlais, Swansea.

The Montagu at Lundy.

Sir Philip Watts has visited the scene of the wreck, and a successful issue of the salvage operations is looked for. In a journey around the coast this week I heard strong expressions of opinion as to the necessity for a harbour of refuge. One captain stated that the Admiralty has regarded the Bristol Channel as too unimportant for national consideration, but must now do something. It is a matter of rumour in the district that the Montagu was 80 miles out of its reckoning; this, of course, looks absurd and will be cleared up at the inquiry. Cardiff has been sending excursion steamers daily to the scene.

The Iron and Steel Trade.

A fair tone characterises the trade generally. Iron ore has been coming in freely, some from Newquay, Cornwall, to Baldwins, Limited, but principally from Bilbao to Newport. Pig iron from Barrow has figured amongst importations, and Newport has been busy in sending steel bars to Lydney, rails to Bristol, and one important cargo to Bahia Blanca. Swansea has imported pig iron and scrap steel; old rails in good bulk have come in from Southampton. Large orders for colonial rails are in hand, also fish-plates for India and South America. Quotations unchanged, steel bars are at £5.

Tin-plate and other Industries.

On 'Change, Swansea, this week it was a subject of comment that the holiday week had not been followed by the usual briskness. The despatch last week was limited to 24,963 boxes; receipt from works, 44,793 boxes; present stocks, 182,350 boxes. Latest report is that the market is quiet, with little business passing. Quotations are unchanged. Bessemer cokes, ordinary size, I.C. 20 × 14, 112 sheets, 13s. 6d. to 13s. 7½d. Siemens, 13s. 9d. C.A. roofing sheets, £9 per ton. Big sheets for galvanising, 6ft. by 3ft. × 30 gauge, £9 7s. 6d. Finished black plates, £9 10s. Block tin is at £177 5s. Lead, £17. Copper, £82 5s. Silver, 30⅜ per oz. Spelter, £27 12s. 6d. Nickel is brisk. Other quotations given on 'Change are:—Pig iron, Bessemer mixed numbers, 64s. 9d. Middlesbrough, 50s. 1d. Scotch, 56s. 3d. Welsh hematite, 70s. to 71s.

NOTES FROM GERMANY.

(From our own Correspondent.)

Iron and Steel in Rheinland-Westphalia.

THE condition of affairs during last week has been most satisfactory in all the principal departments of the iron and steel industry. Demand for pig iron as well as for raw steel continues exceedingly strong, and the manufacturing establishments are also reported to be exceptionally well employed, principally on orders for home consumption. All sorts of railway requirements are meeting with the most active demand, and the number of orders received in the shipbuilding and engineering departments has been steadily increasing. Producers, accordingly, find no difficulty in carrying the raised quotations.

The Silesian Iron Market.

Local as well as foreign inquiry has remained pretty extensive during this week and the last, causing the tendency all round to increase in firmness. Scrap iron was in rising demand all through last month, and even now inquiries come in very freely; dealers have, here and there, been trying to realise higher prices, and with fair success, too, M. 49 to M. 63 p.t. being now the ruling prices for the different sorts of scrap iron.

From the Coal Market.

A most satisfactory condition prevails on the Silesian coal market. Since the beginning of summer daily deliveries have been, on an average, 6600 wagons, and during the first two weeks in May 6604 wagons per day have been delivered, against 5297 wagons in the same period the year before. Also in the coke trade a steady and decidedly favourable business is done. Much the same can be told of the Rhenish-Westphalian coal industry, demand for all sorts of fuel having been exceptionally brisk during the week. The want of workmen continues to the disadvantage of coal owners and consumers. Shipments to the Rhine harbours are insufficient and very irregular. Considerable firmness is experienced in the coke trade, but here, too, a want of workmen has caused delay in many instances. Coal for coke making continues scarce. Dealers and consumers of coal in South Germany complain of getting far less than is required now, demand having increased, while supplies show a falling off against previous weeks.

Position of the Austro-Hungarian Iron Trade.

The consumption of the various articles of iron and steel has been fairly large, and there is, consequently, a good deal of stiffness shown in quotations. Sales of the United Austrian Sheet Mills have been 766,000 q. in the year now past. From the Austrian coal market good reports are given; the outlook generally is fair, and the present demand pretty extensive. The accounts given of the Bohemian brown coal trade during the first five months of present year show an increase in activity in all districts; in the North-West Bohemian brown coal district, for instance, 35,000 wagons more have been delivered than in the same period the year before. The increase in output amounts to about 7 per cent. In May of present year shipments amounted to 12 million q., against 11 million q. in the previous year. Deliveries on foreign account have likewise improved. A rise in the prices for engine fuel is sure to take place on the 1st of July, but will probably not exceed 40 heller per ton.

Increase in Quotations on the Belgian Iron Market.

Both for finished iron and for steel have prices, last week, shown a marked inclination upwards. When the orders previously booked have been executed concessions, which have so long prevented a healthy improvement in the prices for malleable iron, will no more be granted by the works. The rolling mills are all actively engaged; those that are provided with a fair supply in semi-finished steel, purchased at a period when prices were low, are doing a very profitable business now. As a rule, steel bars are being sold at 151·25f. to 152·50f. p.t. for export, and with few exceptions makers have obtained what they asked; the lowest price taken was 150f. p.t. For iron bars 150f. p.t. has been quoted and 146·50f. to 147·50f. is usually paid as the lowest price. Steel bars for home consumption are quoted 160f. p.t.; girders, 150f. p.t. For common plates in iron and steel 170f. p.t. is quoted, Siemens-Martin plates realising 177·50f. to 180f. p.t. At the railway and construction shops a large amount of work previously obtained, as well as a good number of fresh orders, secure a most active occupation for this and the next quarter. A very firm and healthy tone characterises the crude iron department, forge pig selling at 72f. p.t., even when small orders are in question. The market for coal is firm in Belgium. Quotations recently fixed are 13f. to 15f. p.t. for small coal; 13f., 15f., and 17f. p.t. for the different sorts of steam coal. The exceptionally active demand of previous weeks has given place now to a steady and very regular business; during the last week in May a decrease in the number of wagons delivered could be noticed, when compared with the same week in the previous year. All descriptions of engine fuel meet with excellent request.

Iron and Steel in France.

There has not been any material change in the iron industry, and the accounts given are satisfactory, both as regards demand and the condition of prices. Also the coal trade is in a favourable position now, and shows increasing strength.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, June 6th, 1906.

THE special feature this week is the oversold condition of the Bessemer and basic iron interests. There are inquiries for large quantities of both Bessemer and basic, and some sales have been made at the outside prices. There is a scarcity of sheet bar, which has resulted in the closing of some plate mills, and higher prices are probable. Pig iron is selling in a moderate way at the usual prices prevailing for some weeks, and large consumers are disposed to buy in a moderate way on future account. About 20 000 tons of basic pig have been sold within a week at 17·50 dols. per ton at furnace. A large cast iron foundry bought 15,000 tons of iron, and a contract for 50,000 tons of foundry, malleable, Bessemer, and basic are being held up to see which way the market goes. The smaller consumers of iron are not waiting for any change, and there is no good reason at present for anticipating any. Contracts are still coming in for steel rail for next year's delivery at 28 dols., and by July 1st the contracts will exceed 1,500,000 tons. It is not probable that there will be any cessation in demand, for it is known that quite a batch of new railroad building enterprises have been put in shape to buy materials of all kinds for track construction. The bridge builders are buying heavily, and the average monthly business foots up somewhere in the neighbourhood of 75,000 to 80,000 tons, all told. The independent structural interests are grasping a good deal of business, but they are refusing to make any concessions to get it.

The equipment plants engaged in the manufacture of locomotives, stationary engines, gas engines, and motive power capacity of all kinds are all quite busy, and there is no reason for anticipating any other condition of things than now prevails. The bar mills are nearly all working full capacity. Sheet and pipe mills are making full time. The merchant mills are oversold, and the manufacturers of agricultural implements are placing their orders with customary promptness. The copper market is strong, and the absorption of surplus supplies of American copper in China has opened a way for an improving demand. The large electrical concerns and the wire makers have begun to buy liberally for August and September deliveries. Large sales of copper have been made for the Continent, and it is estimated that this month's business will not fall much short of 20,000 tons.

The sale of lead has been confined to rather small lots, and sales of Missouri are made at 5·90. The spelter market is firm at 5·90 to 6. No. 1 ingot of aluminium for re-melting are selling at 35 cents. The quicksilver market is once more active, and business is being done on a basis of 41 dols. per flask of 75 lb. Nickel is selling in large lots at 45 cents, ton lots at 50 cents, and small quantities at 60 to 65 cents.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

WE are informed that the firm of Raine and Co., Limited, has appointed Mr. H. B. Sparrow, of 65, Fenchurch-street, E.C., its London agent.

WE are informed that Messrs. John Turnbull, jun., and Sons, have changed their address of business from 190, West George-street, Glasgow, to Canal Basin Foundry, Charlotte-street, Dobbie's Loan.

WE are asked to state that Messrs. Jay, Broll and Co., of 31, Old Queen-street, Westminster, have been appointed London managers and agents for the firm of Messrs. Wm. Truswell and Son, heating and ventilating engineers, of Newcastle, Staffordshire.

A LONDON company is now in course of formation by Messrs. Brown, Boveri and Co., which will take charge of the interests of the Swiss company in Great Britain, the Colonies, and various other countries. The directors of the English company will be Messrs. Charles Brown, W. Boveri, and C. Baumann, who are also directors of the parent company in Baden, and Mr. A. C. Eborall, who resigns his seat on the Board of Witting, Eborall and Co., Limited, for this purpose. The latter business will be purchased by the new company, and carried on as a part of the business of Brown, Boveri and Co., Limited. As a result, Witting, Eborall and Co., Limited, have ceased trading, as far as new work is concerned, while their work and contracts in hand, and their various British and colonial branch offices and agencies, are being taken over, as far as is practicable, by the new company. The offices of Brown, Boveri and Co., Limited, will be situated—after the 23rd inst.—at Caxton House, Westminster, and on that date Messrs. Witting, Eborall and Co., Limited, are also removing their offices from Temple Bar House to that building, where they will remain until such time as various outstanding matters connected with the settling up of their business affairs have been arranged. The working arrangement which has existed between Witting, Eborall and Co., and Ferranti, Limited, for some time, in respect to switchgear, and other manufactures of that firm, has come to an end, as a result of the new arrangements, and, in consequence, all inquiries for Ferranti material should in future be addressed directly to Hollinwood.

A NEW Darracq-Serpollet steam motor omnibus has completed a trial trip around France, covering nearly 2500 miles in 15 days and finishing without accident. A "non-stop" run of 274 miles was made in 19 hours.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS,** *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.
When the abridgment is not illustrated the Specification is without drawings. Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.
Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

21,430. October 21st, 1905.—AN IMPROVED WATER-TUBE BOILER, *Maschinen und Dampfkesselfabrik Guilleaume Werke, G.m.b. H. of Neustadt-on-the-Haardt, Germany.*

The invention relates to water-tube steam boilers, and has for its object the production of superheated steam as dry as possible and to increase the production of steam. There are two figures. Fig. 2 is a sectional view. There are four horizontal cylindrical chambers or vessels *a*, *b*, *c*, *d*, the ends of which extend a short distance beyond the furnace casing. The water-receiving chamber or vessel *a* is arranged in the front portion of the furnace casing, and has its axis in the line of the water level. A short distance below this water-receiving chamber, and within the furnace, is arranged a second chamber *b*, which is connected directly to the first-mentioned chamber or vessel *a* by a series of tubes *x* within the furnace, and thus is filled with water from such mentioned chamber *a*. The water in this second chamber *b* is the first to be heated. A third chamber *c*, acting as a mud collector, is arranged

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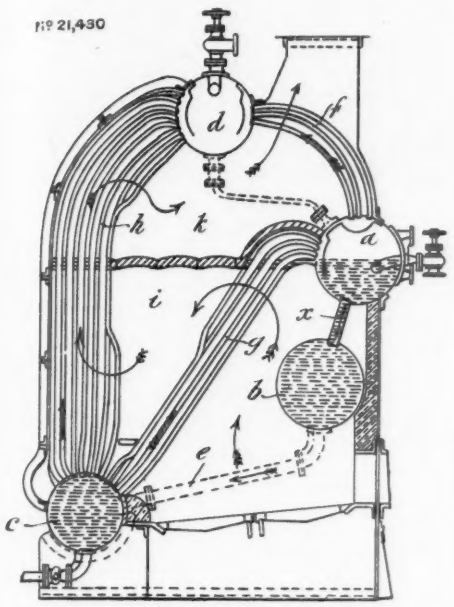

Fig.2.

at the back end, and preferably partly below the level of the fire-bars, and it is connected to the second chamber or vessel *b* by tubes *e* outside the furnace casing, and receives water therefrom. The fourth chamber or vessel *d*, acting as a steam collector, is arranged at the top and within the furnace casing. It is connected to the top of the mud collector *c* by a series of water tubes *h* at the back of the furnace and to the top of the water-receiving chamber or vessel *a* by a series of water tubes *f*, crossing the entrance to the chimney. The chamber or vessel *a* is connected with the mud collector by a series of inclined water tubes *g*, passing diagonally across the furnace. The boiler casing is divided into an upper combustion chamber *k* and a lower combustion chamber *i* by a fire-proof wall or roof at about the water level. The fire gases act on the chamber or vessel *b*, thus warming the water for the first time; they then pass the inclined tubes *g*, and enter the rear part of the lower combustion chamber *i*, where they pass amongst the water tubes *h* at the back of the furnace, and thence enter the upper combustion chamber *k*; finally the fire gases pass to the chimney across the tubes *f*, crossing the chimney entrance.—*May 17th*, 1906.

INTERNAL COMBUSTION ENGINES.

16,679. August 17th, 1905.—IMPROVEMENTS IN INTERNAL COMBUSTION MOTORS, James Dunlop, of 69, Armadale-street, Dennistoun, Glasgow, and D. Stewart and Co. (1902), Limited, London-road Ironworks, Glasgow.

This invention relates to internal-combustion motors operating on the two-stroke compression cycle, and has for its objects an improved arrangement of parts whereby the space occupied by a

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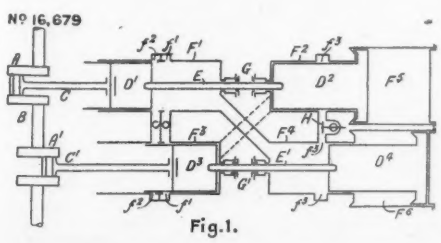

Fig.1.

given power of motor will be less than at present. Fig. 1 shows in horizontal section the arrangement. The improvements consist, first, in arranging the motor with a pair of cranks A A^1 set 180 deg. apart on a crank shaft B. Coupled to each crank by connecting-rods C C^1 in the usual manner are two pistons D^1, D^2 and D^3, each pair tandem on piston-rods E and E^1. The pistons slide in tandem cylinders F^1, F^2 and F^3, F^4, one end of each of which cylinders only is closed, namely, the ends nearest each other. Stuffing-boxes G G^1 are provided in these ends to allow the piston-rods E E^1 to pass through. The motor thus has four single-acting cylinders operating on one pair of cranks, and the four closed ends of the cylinders are close together. These closed ends are arranged to communicate in pairs crosswise—that is to say, the closed end of the front right-hand cylinder F^1 is in free communication at all times with the back left-hand cylinder F^4, and F^2 with F^3. Towards the open ends of the front cylinders F^1 and F^3 two rings of ports f^1, f^2 are formed, so that when the pistons D^1, D^3 are near the ends of their strokes towards the crank shaft they will uncover these ports. The inner rings of ports f^1 communicate with the air pump used to supply the air in this construction of motor. The outer rings of ports f^2 communicate with the gas pump. Towards the open ends of the back cylinders F^2, F^4, a ring of ports f^3 is formed, so that when the pistons D^2, D^4 are near the ends of their strokes away from the crank shaft they will uncover the ports. These ports on the back cylinders F^2, F^4, communicate with the exhaust pipe of the motor, and a valve H may be placed in that pipe, and so operated that it will open communication between the pipe and the atmosphere before the pistons D^2, D^4, uncover the ports f^4, but will close communication before the ports are closed by the pistons on the return strokes. From this it will be understood that the charges of air and gas entering the front cylinders F^1, F^3, willdrive the burnt products out of these cylinders, and also out of the back cylinders F^2, F^4, and that when the valve H in the exhaust pipe is closed, the pressure of the charges may be augmented by the action of the air and gas pumps until the pistons cover the air and gas ports, when the charges in the cross-connected cylinders will be compressed by their pistons moving in opposite directions.—*May 17th*, 1906.

18,245. September 9th, 1906.—IMPROVEMENTS IN PETROLEUM AND THE LIKE INTERNAL COMBUSTION ENGINES, *August Klumpp, of* 11, *Hasenstr., Munchen, Germany.*

This invention relates to that type of internal combustion engines in which the ignition is effected by the heat resulting from the compression. The invention provides a further class of internal combust on engines in which the fuel remains in a channel of the working cylinder during the whole of the compression period where it is prepared for combustion by the compression heat. The moment of ignition, which coincides with that of the diffusion and mixing of the fuel with air, is, however, controlled by positive means. There are four figures. Referring to Fig. 1, which is

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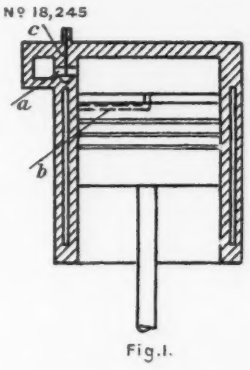

Fig.1.

diagrammatic, the fuel passes through the pipe *c* into the cavity below it, where it remains during the compression period; the piston forces the whole of the air through the channel *a* into the combustion chamber at the side; the piston, before arriving at the end of its stroke, cuts off the channel *a*, and compresses the air left in the cylinder until the channel *b* in the piston coincides with the channel *a*, which takes place at the moment of ignition. The air thus highly compressed then passes through the channels *b* and *a*, drawing with it and highly diffusing the fuel in the said cavity, and enters the combustion chamber for combustion therein. The position of the channel *b* precisely determines the moment of admission of the air.—*May 17th*, 1906.

RAILWAYS AND TRAMWAYS.

21,462. October 23rd, 1905.—AUTOMATIC RAILWAY COUPLING APPARATUS, *Domenico Carcorick, No.* 1, *Via Delgi Armeni, Trieste.*

By means of this automatic railway coupling apparatus it is possible to couple and uncouple the carriages without its being necessary for the man entrusted with this work to place himself between the carriages. Fig. 1 is an elevation. The bar A runs under the whole length of the railway carriage, and has a hook at either end, is utilised in this system by fixing to each end of it a hook of a special form B, running in a head C, and moving along the bar A, a distance which is limited by the length of the slot which serves as guide to the pin D. This head can be moved round through an angle of 90 deg., the hooks turning at the same time by means of the lever F, which brings them either into a horizontal or a vertical position. The hooks B rotate round the pin D, which is common to both, and each round its axis E, which

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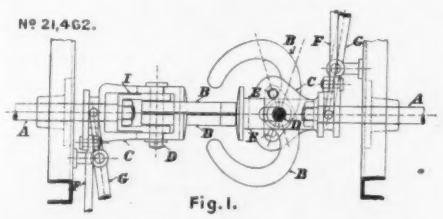

Fig.1.

axes are placed exactly opposite one another, and guide the hooks. The man whose duty it is to couple the carriages must see in what position the coupling hooks of the on-coming carriage are, whether horizontal or vertical, whether shut or open. Suppose for instance, they are in a vertical position, and closed: then the operator, by means of the two levers F and G, places the hooks of the standing carriage in a horizontal and open position, *i.e.*, in an exactly contrary one to that of the on-coming carriage. When the two carriages meet, the closed hooks of the on-coming carriage meet the front part of the head C, which in consequence of the shock, runs along the bar A as far as the slot length of the cut in it will allow. But the pin D being fixed on the bar A by the split-rod 1 the motion of the head, and with it the motion of the guiding-pins E, cause the rotation of the hooks B round the pin D each in a different sense, thus closing them and coupling the hooks of the other carriage exactly like the two links of a chain.—*May 17th*, 1906.

ROAD MOTOR VEHICLES.

10,392. May 17th, 1905.—IMPROVEMENTS IN AND RELATING TO MOTOR VEHICLES AND THE LIKE, Thomas Parker, F.R.S.E., of 1B, Chapel-street, Edgware-road, London, W.

This invention relates to motor vehicles of the type in which the vehicle frame is divided so as to permit the respective parts thereof being brought into various angular position with reference to each other for the purpose of steering. The invention consists in the provision of simple and improved means for effecting this movement of the parts of the divided frame under the ready control of the driver. Fig. 2, a plan of the underframe; the rear frame part *a* is advantageously of a greater length than the front frame part *b*, and the respective frame parts *a* and *b* secured together by means of a joint pin *c*, which passes through a toothed sector plate *d* secured to the front portion of the frame part *b*. The sector plate *d* is provided with teeth *g*, which gear with a pinion mounted

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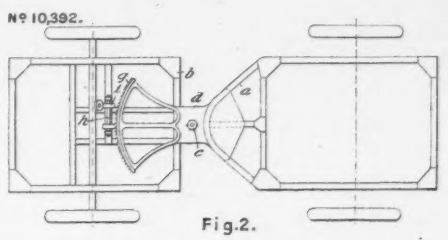


Fig.2.

upon a spindle *h*, upon which spindle also a screw or skew pinion *i* is mounted, which gears with a corresponding screw or skew pinion fitted upon the lower extremity of the steering spindle *j*. The spindle *h* is suitably mounted in position upon the front frame part *b*. By such a connection of the respective parts of the frame the whole of the machinery may be placed in the front frame part *b*. By the extension of the sector plate *d* beyond the hinge pin *c* a very considerable leverage is afforded by means of which the steering may be very easily and conveniently performed.—*May 17th*, 1906.

23,927. November 20th, 1905.—IMPROVEMENTS IN FLEXIBLE TYRES, *Victor-Edouard Belledia, of Rue du Faubourg Saint-Honore, Paris.*

The present invention relates to flexible tyres adapted for application to the wheels of vehicles of all kinds. This invention has for its object improvements in tyres which are composed of springs, the arms of which are curved inwardly towards the centre of the wheel rim and have a tread band fixed between the springs, the improvements comprising the arrangement that within the first springs are fixed smaller springs, termed "buffers," bent C-shape or O-shape, and arranged in such a manner that the inwardly bent extremities of the first springs bear upon them when the pressure of the tyre upon the ground exceeds a certain amount. The springs are protected from mud by a continuous envelope which may be fixed upon the edges of the rim by means of rods. Fig. 2 is a cross section of the tyre. This tyre comprises a hollow rim 1 of metal, upon which a series of springs 2 are fixed, by means of bolts 3, with nuts which cannot be unscrewed. Each spring 2 is composed of a number of thin superposed blades or leaves of steel bent together; their extremities are bent one towards the other at the exterior, and then bent at 4 inwards parallel one with the other. Inside these springs 2 there are fixed by means of these same bolts 3 other smaller springs 5, which may also be composed

Nº 23,927.

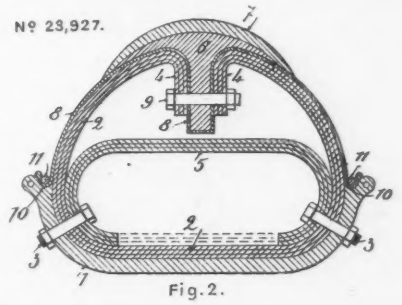


Fig.2.

of superposed steel plates and which are bent C-shaped, their convexity being directed towards the exterior of the circle of the wheel. These springs may also be extended as shown in broken lines. In a free condition the extremities 4 of the springs 2 are situated at a distance from the springs 5, but they are able to bear against them under the influence of a sufficient shock for the purpose of deadening such shocks. The tyre is provided with a tread band composed of a band of india rubber and of a leather band 7, these two bands being stuck together. The india-rubber band is T-shaped in cross section, and its medium rib is embedded in the extremities 4 of the springs 2, whilst its lateral parts extend over the periphery of the series of springs 2; 8 designates an outer cover of rubbered canvas or other flexible and impermeable material which is arranged around the series of springs 2. In order to avoid any break in the continuity of this cover, it is made of sufficient width to enable it to form a fold between the extremities 4 and to surround the rib of the band 6. Bolts 9, with nuts capable of becoming unscrewed, render the extremities 4, the outer cover 8, and the band 6 solid one with the other. Further, the edges of the cover 8 are firmly fixed upon the edges of the rim in channels 10 formed in these edges by means of rods 11.—*May 17th*, 1906.

FURNACES.

9952. May 11th, 1905.—IMPROVEMENTS IN AND RELATING TO FURNACES, Joseph Devonport Finney Andrews, 2, Park-avenue, East Sheen, S.W.

This invention relates to furnaces for the complete or smokeless

Nº 9,952.

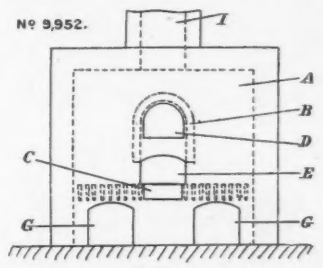


Fig.1.

combustion of fuel which usually produces considerable smoke in its combustion. In order to effect this object in its simplest form, a chamber of non-combustible material is constructed with a partition of non-combustible material dividing the chamber into two compartments. The partition is fixed gas-tight at all edges, and has an opening from one chamber to the other in any suitable

position. In one of the compartments is an opening for the insertion of fuel. The combustion chamber has an opening for the admission of air, and also a flue or other means of creating a draught. When fuel has been inserted and heated in the fuel chamber decomposition will take place, resulting in combustible gases and coke. The gases pass through the opening in the partition into the combustion chamber. This is effected by closing the fuel chamber gas-tight except the opening in the partition, so that the gas has no other means of escape, or by providing an opening to the air in the outer wall of the fuel chamber, and allowing the down draught created by the flue or otherwise to draw air in at such opening and through the fuel and the resultant gases through the opening in the partition and into the combustion chamber. When the gases enter the combustion chamber they combine with the air, which is admitted to it by a suitable opening, and burn. In doing so the partition becomes heated. The decomposition of the fuel in the fuel chamber is supported and continued by the combustion of its own products acting indirectly by heating the containing wall or walls surrounding the fuel. There are two figures. Fig. 1 is a diagrammatic elevation. The fuel chamber is placed within the combustion chamber. B is the fuel chamber, which is made in the form of a retort open at the bottom, but closed by the walls of the combustion chamber A at both ends. C constitutes the bottom of the fuel chamber. D is an opening into the fuel chamber through one of the walls of the combustion chamber. E is another opening through which the fuel can be stoked. G G are openings to admit air through the fire-bars and up round the outside of the chamber B and away by the flue 1.—*May 17th*, 1906.

FANS.

18,006. September 6th, 1906.—IMPROVEMENTS IN AND RELATING TO VENTILATING FANS, BLOWERS, AND THE LIKE, R. P. Wilson and A. G. Marshall, both of 66, Victoria-street, Westminster, London, S.W.

This invention relates to fans, blowers, &c.—for example, as are used for ventilating and cooling purposes, and more particularly to those driven by electric motors. Ventilating devices of the type indicated have been mounted hitherto in such a manner that

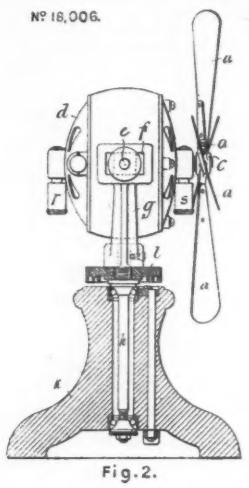


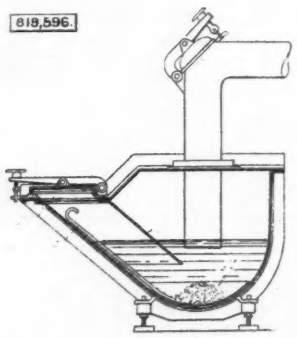
Fig. 2.

the stream of air delivered by them constantly maintains an invariable direction unless the position of the fan or the like is bodily altered by hand or by other extraneous means. This invention consists in utilising the fact that the fan forms part of a rotating system to obtain a gyroscopic processional movement of the fan's axis. Fig. 2 is a side elevation partly in section of an electric fan constructed in such a manner that the direction of the air current caused thereby is varied by reason of gyrostatic action. The fan has four blades *a* mounted on arms *b* projecting from a hub *c*, which is clamped to an axle rotatable in bearings on a closed framework *d* provided with ventilation openings *i*. The axle also carries the armature of an electric motor—not shown—revolving between field magnets—also not shown—carried by the framework *d*. The framework *d* is mounted so as to rotate in bearings *e*, these bearings being in the form of square blocks capable of adjustment in slots *f* in the arms of a bracket *g*. The axis of rotation of the armature and of the blades of the fan is at right angles to the axis of rotation of the frame *d*, carrying the field magnets, both these axes being normally in a horizontal plane. The bracket *g* is fixed to the spindle *h*, rotatable on ball bearings in the pedestal *k* of the apparatus. This spindle also carries an insulating block *l*, having grooves on its under side in which contact pieces *m n* are mounted, these contact pieces being adapted to make contact with the contacts *o p* on the pedestal. The contacts necessary for the operation of the motor can thus be made, whatever may be the position of the fan relatively to the fixed part of the apparatus. In order to introduce a couple acting about the axis of the framework *d*, adjustable weights *r s* are mounted on this framework.—*May 17th*, 1906.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

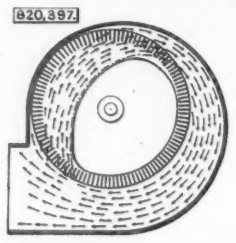
819,596. HYDRAULIC CONDENSER, *R. Reister, Dessau, Germany.—Filed September 15th*, 1905.



Inside the condenser is fitted a removable scoop or shovel in which the pitch or tar deposited by the gas is collected. The shovel can be withdrawn through a manhole. There are four claims.

820,397.—CENTRIFUGAL FAN OR PUMP, *S. C. Davidson, Belfast, Ireland.—Filed October 24th*, 1904.

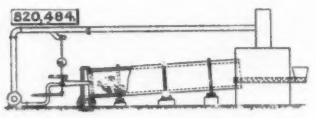
This invention cannot be better described than by the first of seven claims. A centrifugal fan or pump comprising a snail casing, and a fan wheel mounted excentrically thereon, whereby when operating against a pressure or suction, there is established a current of fluid re-entering said fan wheel and moving across the



intake chamber thereof, that portion of said intake chamber traversed by said current being practically unobstructed, and said fan or pump having its eye disposed with its greatest area of inlet on the side of the intake chamber, which is opposite to that across which said current passes.

820,484.—PROCESS OF BURNING CEMENT CLINKER, *H. L. Doherty, Madison, Wis.—Filed December 12th*, 1905.

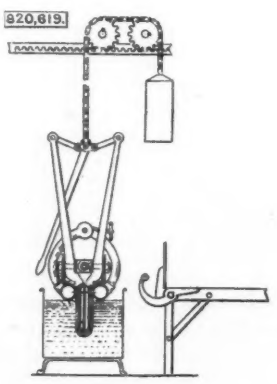
This invention consists in burning cement in rotary kilns, with powdered coal fuel. The coal is introduced in a single jet, with



sufficient air to complete combustion, but the air is diluted with carbonic acid. The amount of dilution is varied from time to time, by which means incrustations on the kiln are prevented. There are nine claims.

820,619. APPARATUS FOR TEMPERING OR HARDENING STEEL, *H. H. Bickford, Elmira, N.Y.—Filed June 6th*, 1905.

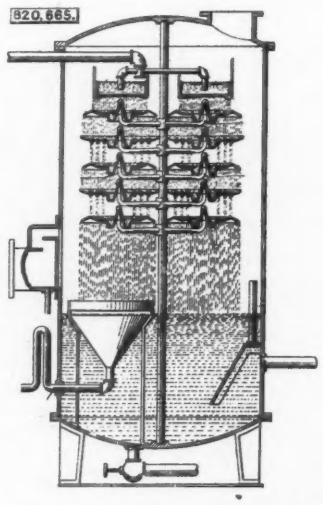
This invention consists in shutting up the article to be tempered



in a box, whereby direct contact with the heating medium is avoided. Air under pressure is to be forced into the box, so as to exclude the heating liquid. There are three claims.

820,665. FEED-WATER HEATER, *H. C. Moore, Atlanta, Ga.—Filed June 23rd*, 1905.

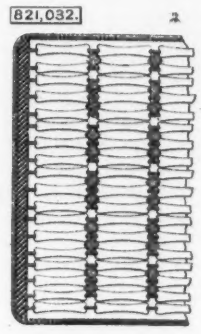
This invention consists in placing in an exhaust steam chamber a central stand consisting of a bar carrying radiating arms upturned



at the ends, which are sharpened, and on each of which is placed a circular tray. The object is to make these trays self-levelling, so that a uniform discharge over their edges will take place. There are seven claims.

821,032. STORAGE BATTERY, *T. A. Edison, Llewellyn Park, N.J., assignor to Edison Storage Battery Company, West Orange, N.J., a Corporation of New Jersey.—Filed September 28th*, 1904.

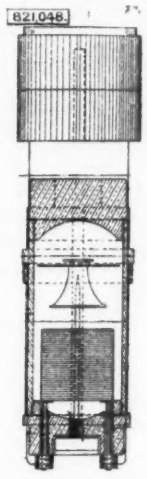
The single claim runs:—In a storage battery employing an alkaline electrolyte and active materials containing iron and nickel respectively, the combination of a series of grids or plates carrying pockets for the iron composition, and a series of grids or plates carrying pockets for the nickel composition, said latter grids being placed in pairs between the individual grids of the former series,



and the volume of active material carried by each grid of the battery being substantially the same, substantially as set forth.

821,048. MEANS FOR SURVEYING BORE-HOLES, *H. F. Marriott, Parktown, Transvaal.—Filed August 30th*, 1904.

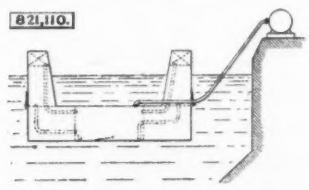
This invention consists in placing a compass needle in a plastic substance such, for example, as wax, which can be melted by passing a current of electricity through a wire embedded in it.



The instrument is dropped down the bore-hole, the current passed, the needle liberated so that it can take its ore deflected position, the wax is allowed to solidify, and the instrument withdrawn, the position of the needle at the bottom of the bore-hole being recorded. There are six claims.

821,110. FLOATING DOCK, *A. Mehlhorn, Dietrichsdorf, near Kiel, and P. von Klitzing, Neumühlen, near Kiel, Germany.—Filed July 30th*, 1904.

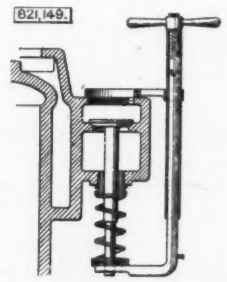
This invention consists in establishing air-ways between the



various sections or compartments of a dock and a large reservoir on shore, in such a way that water can be drawn into or expelled from any compartment. There are three claims.

821,149. DEVICE FOR FACILITATING THE REMOVAL OF VALVES FROM VALVE BOXES OF INTERNAL COMBUSTION ENGINES, *G. J. E. Alphandéry, Chaumont, France.—Filed November 8th*, 1905.

This drawing explains itself. A bent rod is arranged to carry



the pull-down spring. The end of the bent arm engages with the toe of the valve stem, and a cross-handed nut bears on the tube in which the rod slides. By turning the nut the valve is lifted. There is only one claim.

THE British Consul at Bilbao states in his report for the past year that shipowners at Bilbao are still endeavouring to obtain increased protection and facilities for native shipping by the abolition of the excessive dues and taxes imposed on the purchase and registration of foreign ships and foreign machinery, as well as of iron material employed in repairs, &c., to avoid which purchasers of foreign vessels place them under foreign flags. For instance, last year, five large steamers were purchased for Bilbao, and are flying the Honduras or Uruguayan flags.

ITALIAN INDUSTRIES.

(By our Special Representative.)

No. VIII.*—TEXTILE INDUSTRIES.—PART I.:—SILK.

IN my first article on the power stations of Italy, I called the science of hydraulics here the "great mother-science," from which our industries derived their being, their nourishment, and their present vitality. I should have said, perhaps, with more exactness "mother to a large number of our industries, and foster-mother of them all." And among the many daughters which she has adopted, the Italian textile industry is the oldest and the most healthy, and day by day is making itself more felt as a factor to be reckoned with in the commerce of the world. Putting aside the general causes of this prosperity, causes which have been already referred to, a primary reason is to be found in the fact that Italy, in the matter of the raw product to which the textile industries owe their life, is the country most favoured by Nature in the whole of Europe.

Fig. 1 WORKS FOR THE MANUFACTURE OF ARTIFICIAL SILK

Whilst other nations depend almost entirely—viz., with the exception of a negligible quantity of home-grown wool—on foreign countries for their raw material, Italy is responsible for five-sixths of the total crop of all the silk-producing countries of Europe; besides this she has a large and ever-increasing production of flax, hemp, and jute, which, though as yet not great enough to permit the exportation of the raw material, still does much to account for an export, under these three heads, of 40,000,000 kilos. of the finished article.

In the northern provinces, and especially in Lombardy, the silkworm represents the principal riches of the peasant. It is considered by him as his first "crop." Thirty days of very hard work and of self-denial—and it is self-denial, for the Lombard peasant in this interval gives up his whole house to the silkworms, and sleeps for the few hours in which sleep is allowed him in the hayloft—and then the reward is gained. The money is forthcoming which enables him to provide for the exigencies of the tax collector, and to have something in hand until the moment in which he is able to realise his other products.

The silkworm in Italy not only yields enough to supply the home market, but also enables the country to export raw and spun silk to the value of 300,000,000 lire, and woven silks to the value of 100,000,000 lire yearly.

This industry is not a new one, as so many other Italian industries are. For its age it may be compared to the celebrated glass-blowing industry of Murano, whose artificers were considered by the Venetian Republic worthy husbands for the daughters of the highest nobility of the "Queen of the Adriatic." It is well known how the Chinese kept for 3000 years the monopoly of the precious insect, and how they punished by death anyone who revealed the secrets of the trade or who gave to a foreigner the eggs from which their riches were so much derived. It is also well known how the Emperor Justinian obtained these eggs by means of two missionaries sent out on purpose, who returned with their hollow sticks full of the precious "seed." From that time the industry was established in the Peloponnesus.

The first place in Italy where the cultivation of the silkworm was established was Sicily, and it is probable that the new industry was due to the military expedition of King Roger of Sicily into Greece. From Sicily the lately discovered fount of riches extended itself into Calabria, and almost at the same time we find it springing up in Venice and in Genoa, for the identical reasons for which it had already brought itself to light in Sicily, namely, in consequence of naval expeditions to the Oriental Empire.

From that moment the silk industry of Italy has made ever increasing progress. In the Middle Ages the country may be said to have possessed almost a monopoly of this branch of trade, and at the present day the production and export of Italian raw and worked silk is one of the most important items in the general commerce of the entire globe.

Never has this industry enjoyed such prosperity as it does at the present moment, and this fact is undoubtedly due to the new system of selection of the eggs. In consequence of the terrible scourge of the *Pebrina*, which passed like a wave of destruction over the country in the latter part of the last century, and nearly ruined all who had to do with the silk industry, the Government appointed a commission of experts to inquire into the means whereby this dreaded plague might be averted in the future. They came to the conclusion that the seat of the disease lay in the egg itself, and Signor Cantoni, together with M. Pasteur, of Paris, devised the system of the cellular segregation of each female moth, now so universally adopted here. This measure, combined with the establishment of trustworthy commercial houses, which only put on the market healthy eggs, has worked wonders to eradicate the evil, and as the peasants year by year begin to understand that it is to their interest to buy their eggs from one of these large dealers instead of producing their own stock, it is to be hoped that in the near future the *Pebrina* will be stamped out altogether. Another reason for the immense production of the last few years is an interesting one. I owe the theory to the courtesy of Commendatore Erasmo Mari, of Ascoli Piceno, one of the chief houses to which I referred above for the sale of silkworm eggs—see Fig. 2—and one whose success in his trade may fully warrant him in saying that the theory has passed into the realm of practice.

Signor Mari's experience led him to conclude that the cause of the general weakness of the insect, and its consequent propensity to catch diseases, lay in the fact of too much interbreeding. He therefore ordered consignments of eggs from China and Japan, and the results of this introduction of new blood were so satisfactory that he continues year by year on the same system, crossing and recrossing the Italian indigenous breed with the foreign stock, and acclimatising the cross-breeds for two years before putting the product on the market. The cocoons selected for stock are placed each in a separate compartment, and in tiers of shallow trays, the male cocoons, known by their slighter weight, being separated from the female cocoons in order to facilitate operations later on. Then, as the moths emerge, they are taken by a specially skilled man, who gives to each female her male. This operation requires great quickness of eye and lightness of hand, as, of course, in a large establishment scores of moths are bursting from the cocoons at the same moment. Each female is then taken and placed separately in a little paper bag—the cellular segregation system above referred to—where she lays her eggs and dies. These little bags are then hung up in long strings in an airy room to await further manipulation—see Fig. 3, page 647, the reproduction of one of the rooms destined for this purpose in Signor Mari's factory. The bags are then handed over to the crushers, who take out each dead moth, crush them one by one in a little mortar, and pass them on to the microscopical examiners, who again in their turn hand them over to the controlling experts for a second microscopical examination. If any germs of infection are found in the fluid that comes from the body of the dead moth, the little bag from which she was taken and which contains her eggs is immediately burnt. The sterile eggs, known by their bright yellow colour as against the greyish tint of the fertilised eggs, are then destroyed, and the rest are ready for the crop of the future year.

I have gone somewhat at length into this industry on account of its wonderful development in the last decade, and of the pitch of scientific perfection which it has attained in the hands of these expert specialist firms.

In Fig. 4 will be seen a reproduction of the department in which the dead moths are crushed and the first selection takes place. Fig. 5 represents the first microscopical examination, and Fig. 6 the last controlling examination, also microscopical. The above photographs are all taken in the works of Commendatore Mari, of Ascoli Piceno.

The life and metamorphoses of the silkworm are too well known, from futile experiments made in that direction in our childhood, to warrant my going into the matter at any length. The principal centres of production here are Lombardy, Piedmont, and Liguria. The industry is, however, also very flourishing in Tuscany, and is beginning to lift up its head successfully in the southern provinces, where the cocoon, though produced in smaller quantities, is nevertheless, for climatic reasons, of perhaps superior quality for hardness and silk-producing properties.

The industry of the rearing of the silkworm is practically in the hands of thousands of peasants throughout the whole of Italy, and the success of the crop depends almost entirely on the capacity of the individual. The precautions to be exercised are without number, and the care must be never-ceasing. It may be truly said that few peasants in the Como district ever sleep in their beds during the first two weeks of June.

The cocoons, when sold, are put into huge ovens, where, by means of baking or steaming, the chrysalis inside is shrivelled up, because to allow the moth to escape from the cocoon would mean spoiling the silk. There are many ingenious kinds of apparatus for this operation, among the best known for efficacy and celerity being the ovens of Signori Bianchi-Dubini, of Milan. After the cocoons have been baked, they are taken to the spinning factories, where they are put into basins containing boiling water, and the silk is drawn off from them on wooden frames revolving by water or steam power. From these frames it passes on to the spindles, and, after several processes, is twisted into the hanks, about a foot long, so well known in commerce, and is made up in packets to be sold to the dyers and weavers.

The number of basins for drawing in this country are about 63,000, of which 45,000 are in Lombardy, Piedmont, and Liguria, and there are about 200,000,000 silk spindles. These data are only approximate, and are considerably below the real figures, which would be very much increased if it were possible to arrive at any sort of just estimate of the immense number of hand spindles in the country. These, together with the innumerable hand looms, of which the Romagna district is full, constitute thousands of little "family industries," and any information about them is courteously mis-stated by the peasant proprietor, for fear that his dreaded enemy the tax-collector, should bring him to account for the small gain derived from them.

To have an idea of the importance of the raw silk industry in Italy, it is enough to say that the country produces the greatest amount in the world after China and Japan that out of the total mass of silk of Europe and Asia, which is poured every year on the European and American markets, Italy produces almost the quarter, and that the average crop of cocoons between 1900 and 1904 was about 55,000,000 kilos. a year. The crop of 1904 was an exceptionally large one, being between 60 and 65 millions of kilos. for an approximate value of 200 million lire.

Fig. 2—COMM. ERASMO MARI'S ESTABLISHMENT AT ASCOLI PICENO

Our production in the raw silk market of Europe may be gauged from the following table:—

	Kilos.		Kilos.		Kilos.
1885.—Italy,	6,000,000 ...	France,	4 500,000 ...	Germany,	800,000
1895.— ,,	9,500,000 ...	,,	7 000,000 ...	,,	1,500,000
1905.— ,,	11,000,000 ...	,,	9 000,000 ...	,,	1,000,000

* No. VII. appeared June 15th.

And here it may be well to note that, for the hundreds of accessories, great and small, necessary for the trade, from the coming to life of the little grub up to the mechanical weaving of the silk, Italy is, and has been always, dependent on herself. The process of drawing and spinning, once effected entirely by hand, has progressed with modern science, and the firm of Giovanni Battaglia, of Luino, produces electrically-driven machines for these purposes, which save an immensity of time and labour. Their spinning and twisting machines are especially remarkable, not only from the point of view of their celerity, but from the fact of the extremely ingenious automatic arrest of any particular reel in which a breakage of one of the threads of silk may occur.

For the scores of delicate little blown glass accessories, fine enough to be able to conduct, to thread, and to twist a product of the gossamer strength of silk, Fratelli Bettini, of Lecco, hold, perhaps, the first place.

The great silk-spinning industry of Italy was, until not long ago, in the hands of thousands of peasants' families, who worked in detail with their wooden hand spindles; but modern appliances combined with the industrial trend towards enterprises conducted on a large scale, have contributed to the formation of companies, and to the introduction of the most perfect mechanical looms, each of which corresponds, in its output, to that of three hand looms. These large companies seem hitherto to have only had the happy effect of increasing the production and export, without interfering with the gains of the small proprietor. Among the spinning companies may be noticed Banfi, of Milan; Dubini, of Milan; the "Setificio di Vimercate," and Craponne and Co., of Milan; while among the spinners of waste, one of the most powerful companies is the "Società per la Filatura di cascami di seta," of Milan.

For the dyeing of the raw silk, Italy was, until not many years ago, entirely dependent on the foreigner, but the art has made immense progress lately, and firms like the "Unione Industrie Seriche" of Como, Noseda of Como, Allamel of Cernobbio, the "Tintoria e Stamperia Comense," Malizia of Milan, Rusconi of Milan, and many others can now vie in the excellence and permanency of their colours with any French or German houses. As an illustration of the pitch of perfection to which the dyeing industry has arrived in Italy, the visitor to the Milan Exhibition may observe the frieze which runs round one of the large rooms, a frieze made entirely of silk, and containing in all no less than 65,280 different grades of colour.

The silk weaving business in Italy is only less important than the production of the raw silk itself, but, unlike the latter, the various phases of the industry are so well known that it would be superfluous to go into detail. There are about 25,000 looms, employing about 30,000 hands, while among the best known weaving companies may be mentioned the "Tessiture Seriche Bernasconi" of Cernobbio, the "Unione Industrie Seriche" of Como, and many others, especially in the Como district, where the heart of the industry may be said to lie.

In the weaving branch of the silk trade, however, Italy has not, as yet, been able to emancipate herself from foreign help, as her machine looms are almost entirely of Belgian or German manufacture.

But this subject would not be complete without noticing the fact that the art of making brocades, damasks, and the finest silk coverings for furniture and walls, the art for which Italy was so justly famed in the Middle Ages, still lives and prospers in the country. The firms of Carrugo and of Osnago Civelli, of Milan, working as their fathers did before them with wooden hand looms—machine looms being useless on account of the complicacy of the patterns and the thousands of different coloured threads—may be justly said to rival any of the mediæval artists whose gorgeous stuffs may still be seen in the palaces of Venice and of Genoa.

To all these old branches of the great silk industry of Italy may be added now a new branch, that of the making of artificial silk from cotton waste, an industry originating in Frankfort, and which has now made its appearance at Pavia, where the company's works—see Fig 1—cover 65,000 square metres.

Such is the present state of the great silk industry of this country, an industry which employs more than 200,000 hands, and which last year was responsible for an export trade for the worth of 573,000,000 lire—an industry which, in 1905, exported into the United States alone, goods to the value of 16,630,000 dols.—an industry which has been in times past, which is, and which will ever be more so, one of the principal factors of the prosperity of the country and the glory of the Italian nation.

THE COMMERCIAL ORGANISATION OF ENGINEERING FACTORIES.

By HENRY SPENCER.

No. IX.*—COSTS DEPARTMENT *(continued)*.

Finished stores.—Before passing from the question of materials, reference must be made to the record of parts delivered to "finished stores" room from the various manufacturing departments, for if an accurate record is to be kept as to the stock of finished parts on hand, and which do not come under the head of "work in progress," it will be necessary to keep a similar account to that furnished by "Finished Stores Received" sheet—Fig. 70. But while it is obvious that car details of such value as is represented by finished stores should be under close observation and control, it will also be readily conceded that, for the sake of convenience, there are certain units and fitted-up sections that may advisedly be permitted to remain outside the store room. Under such circumstances even, the storekeeper should be acquainted with the facts, and be nominally responsible for the records as to their subsequent disposition, as otherwise there is a real and grave risk that such parts will unaccountably disappear. Undoubtedly a lax system of stores control will result in such disappearances, which, traced to their source, would probably be found to arise from a car repair job, and the penalty paid for the laxity in this connection may be the gratuitous replacement of some very costly part. Only they who have actual experience can know how important this question is, and a conscientious, experienced employé may easily save the amount of his salary by maintaining a keen look-out for leakages of this nature. But this record of "finished stores" received from the various departments has another important function, for the value of cost records depends entirely upon the necessary information as to what quantities are represented by the labour costs shown on the job cards. Reference to the latter will show that provision is made at the foot of the card for recording deliveries to the stores room, and in this way the parts actually finished are compared with the rough material issued against each job.

FIG. 70.—*Finished Stores Received Sheet. Size, Foolscap.*

FINISHED STORES RECEIVED.

Month of.....19 .....

Date.	ex Factory Order No.	Card No.	Description.	Stores Ledger.

Labour costs.—The question as to how the actual time spent on the various batches of details may be correctly ascertained is as complex as it is important, and the difficulties are all the greater when the task is to ascertain the labour costs on such numerous small jobs as come under the head of drilling, key-waying, slotting, &c. With a bonus or premium system in vogue and running concurrently with the time rate system of pay for such jobs as cannot conveniently be given out on a bonus job note, the necessity for a reliable record becomes more acute, for it cannot obviously be permitted that a man may make capital out of one at the expense of the other job. Yet this is what may often occur unless the time charges are carefully checked. In some factories the foreman or his clerk have to perform the clerical work that is inevitably involved, while in others a clerk from the costs office makes a round of the shops once each day to collect the figures. Some shop accountants permit the workman to write up his own record on a weekly time sheet, and others prefer to have a time sheet for each day. But a foreman is better employed when unfettered with this responsibility, and the figures are more satisfactorily obtained by a man not under his direction. To send a clerk on a daily patrol of the shops simply duplicates the work without ensuring even reasonable accuracy. The daily time sheet lends itself to veiled inaccuracies, while to put a weekly time sheet into the hands of a workman reveals a palpably unreliable system that merely results in a collusive, neglected compilation of figures that are intended to obscure his incompetence and delay the collection of the desired data. How, then, can the work be satisfactorily carried out, without placing too great a drag on the first duty of the factory, *i.e.*, maximum production. One instinctively turns to the mechanical time recorder for a solution of the matter, and there is certainly much to be said in favour of the "Rochester Card Recorder." This machine is in many respects similar to the "Bundy" machine already referred to, and will serve 100 men admirably, showing results which make for both efficiency and economy, provided the department is not a scattered one. In the case of fitters, for example, of whom 100 may be employed in very close proximity to each other, the time of the squad could be ascertained by the use of this recorder with absolute accuracy by purely mechanical means, and with the minimum amount of clerical co-operation.

Time slips.—For a more scattered department, such as the machine shop or the erecting shop, the periodical visits to a time-recording machine would absorb too much time, and the work would be disposed of much quicker if a written time sheet be adopted. The form shown by Fig. 71 is one that has been found more uniformly satisfactory in actual practice than either the weekly or daily sheets previously referred to. The clerical work may be done by a job clerk in each department if desired, but, as a rule, it will be found that the turner or machinist has ample time for this after setting up his job. Each man is provided with a pad of fifty time slips, cheaply bound and perforated for tearing off, which he hangs up close at hand. They are issued to him from the Costs Department, bearing his name and shop number—the work of a boy with a rubber stamp outfit.

The first job of the week would be entered in the above form, the order number and card number—if any—written on the upper portion of the next slip immediataly underneath before tearing off the top slip for the foreman's signature. The slip is then placed in a box as the workman goes out for breakfast or lunch, as the case may be, and the box is afterwards cleared by a boy from the Costs Department. On finishing the shafts, the order number, &c., of which the workman entered on his time-slip beforehand, while his tool was taking its first cut, he will enter the time and date, and set up his next job. His foreman will tell him the name of the job and its order number, and it is the work of a moment to note the same on his slip. In this way he reports the work of the week, and at stopping time on Thursday—which is usually recognised as week-end in the wages department—each workman places a time-slip in the box showing the number of the job he had in the machine at stopping-time, which is identical with that on his next slip, which commences a new week. How readily the man grasps the idea will be proved by trial, and one prominent feature is that no mental calculation is asked for. Seeing that each slip is signed by the foreman, it will be a risky venture to attempt a false time charge, and the manner in which the slips are linked to each other is unmistakably a good guarantee that jobs will not be omitted.

FIG. 71.—*Time Slip. Size, 5in. by 3½in.*

Date, 20th July, 1906.

Mr. Adams. *No.* 336.

Stopped work on

Order No...... ..... *Card No.*..... ..... *at* .....*o'clock, and started to Rough Turn Shafts.*

.....

For Order No. 3230. *Card No.* 571.

E. H., Foreman.

Date calendars.—It is very essential that the correct dates shall appear on the time slips, and as an aid to the man, light wooden racks are fixed in a conspicuous position, and arranged to exhibit numbered cards, printed black on a white ground, to serve as date calendars, being changed each morning by a shop apprentice.

Management of workmen.—In a work that is so closely akin to the internal administration of the factory, it will not be considered an act of trespass to refer to the efforts made in some establishments to raise the tone and standard of intelligence of the men by encouraging them to co-operate with the management by suggesting improvements in the shop system and equipment. Such suggestions are made in writing, and, in strict *incognito* as to their origin, referred to a shop committee for criticism. If adopted, their value is assessed by the committee, and money prizes paid each month for the best suggestions. Reading rooms for the use of the men during the lunch-hour, and equipped with suitable periodicals, of which there is always a plentiful supply in the offices, are always appreciated under proper direction, and tend to enlist the interest of the men in questions of a practical character.

Technical education of apprentices.—The author has in mind a well-known successful firm, which is raising up an educated class of workmen, who will bear comparison with the *personnel* of any contemporary firm, either at home or abroad, and, judiciously handled, will remain one of its most valuable assets. The apprentices are encouraged to attend the local well-equipped technical school, their fees and the cost of text books, &c., being paid by the firm, prizes being offered to all who achieve success at the annual examination. The keenness and friendly spirit of rivalry on the part of the apprentices is very pronounced, their work of a very high order, and the well-meant intentions of the firm are appreciated very greatly. Undoubtedly, it bespeaks an admirable spirit, and the mutual reward must follow as a natural sequence.

FIG. 72.—*Weekly Time Sheet. Size, 8½in. × 10½in.*

Name..... *No.*.....

Rate..... *Dept.* .....

....*Ltd., London.*

Workman's Time Sheet, Week ending.....190.....

Factory Order No.	Card No.	Description of Job.	Machine Tool Nos.	Ordinary Time. F	S	M	T	W	Th	Total.	Overtime. Th	F	S	S	M	T	W	Added Time.	Total Overtime.	Gross Total.	Amount.

* No. IX. *(continued)* appeared June 22nd.

Official labour records.—Following the collection from the factory of the various time charges against the current jobs in hand, the time clerk prepares the official records of the same for posting against the respective costs accounts. In this connection the time sheet shown in Fig. 72 is recommended as a convenient, successful method of collecting each day's jobs in a weekly summary, preparatory to checking the total time charges with the timekeeper's record and the wages earned on each job with the total amounts appearing on the pay-roll, so that there need be little fear of incorrect postings in the costs records with the attendant difficulty in balancing. They who have experience of the worry and loss of time incurred in tracing such incorrections will appreciate the assistance that is afforded by this preliminary precaution. Bonus balances will be shown on the time sheet against the various order numbers referring thereto, as also the time charges against outdoor jobs with railway fares, board allowances, &c., so

that a complete statement appears as to the time worked by each man and the amount of wages earned.

The use of loose sheets is far more advantageous than a book record of this character, in that the work can be distributed among two or more clerks, not only in the course of writing up from time slips, but also for comparison with the timekeeper's record of the readings taken from the "Bundy" recorder, and with wages book. Then when this balancing is found correct, posting into costs accounts is greatly facilitated by the suggested distribution of the work.

Job slips—The loss of time that is occasioned in a large office in consequence of the wrong order numbers that are repeatedly appearing on time slips and kindred records is so considerable as to render the "job slip"—Fig. 73—almost indispensable. The trouble of writing this is very insignificant as compared with that of clearing up such inaccuracies, and as the slip accompanies the job when given out by the foreman, the possibility of any misunderstanding between him and his men regarding the correct order numbers is very remote.

FIG. 73.—*Job Slip. Card 5in. by 3in.*

JOB SLIP.

Shop Order No. .....
Card No. .....
For .....
Class .....
Drawing No. .....
Pattern No. .....
Men's Nos. .....
Dates .....
Date completed .....

This Card must be held by the workman who is doing the job. When he finishes the work he will hand this back to his foreman, along with the job to be checked.

But the foregoing considerations do not exhaust its utility as an aid to the foreman, taking the machine shop as an example. The "Job Slips" are placed vertically in a wooden drawer of suitable capacity, and arranged by the foreman behind guide cards bearing the names of the various operations on machine tools, *e.g.*, automatic lathes, boring, drilling, grinding, milling, &c. They enable him to see at a glance whether he has sufficient work in hand to meet the demands that will be made upon him during the day, and to make due provision, and assist him to keep in touch with the many parts both in hand and in abeyance. On the completion of the work to which a job slip has reference, its return to the costs department will be followed by due reference to the cost card, which is added and ruled off.

Cost cards.—Referring to the schedule of parts that is issued for the guidance of departmental foremen, it will be remembered that each batch of parts is allied to a card number, which is referred to also in the job slips and the time sheets. In thus dividing up the sectional details of the cars, and marking the distinction between the different batches of parts, we are enabled to determine the cost of the various component details, and distinguish hubs from axles, gear wheels from their pinions, engine casings from cylinders, and so on; and from this subdivision to compile comparison costs with a view to throwing up into prominence any excessive or decreased costs that are disclosed by the cost cards, Fig. 74.

FIG. 74.—*Cost Card. Size, 5in. × 8in.*

Card ..... *Pattern* ..... *Description* ..... *Class*
Shop Order ..... *Drawing* ..... *Quantity* ..... *Material* .....

Date.	Operations.	Time charges. No.	Hours.	Rate.	Labour dissection. Lathe.	Drill.	Slotting.	Planing.	Wheel cutting.	Fitting.		Mark off.	Forge.	Labour Cost.
Received Finished Stores	Date													
	No.													

FIG. 74.—*Cost Card, reverse side.*

MATERIAL FROM STORES.

Date.	Reference.	Description.	Weight.	Rate.	Value.
Selling Price:	Agency	Material Cost			
	User	Labour ,,			
		E.C.			
		Total Cost			

These cards are filed vertically in a cabinet of drawers, each of which is sufficient to contain 1000 cards, and guide cards are used for a numerical classification in the order of the card numbers. It will be noticed that the cost of material, taken from the storekeeper's records of stores issued and returned, appears on one side of the card and the labour costs on the other, being posted from the time sheet—Fig. 72. There are also columnar dissections for the various operations, showing the number of hours represented by each, as a first step towards the allocation of departmental establishment expenses, and the record as to deliveries to finished stores room shown at the foot of the card, is obtained from the sheet referred to by Fig. 70. The cost cards in any one drawer constitute a full and complete record of the production costs of one batch of cars, not only as to details referred to in the shop lists, but also as to subsequent fitting and erection in accordance with schedule requisitions, the whole of that batch of costs being collected in the "car costs" book to be described later. The left-hand side of this book is virtually a specification in detail prepared similarly to the shop lists, the costs of manufacture being copied from the cost cards, and the remaining costs of parts procured from outside sources obtained from a card index precisely similar to that referred to in Fig. 32. A final summary of the sections of "car costs" serves the purpose of an index to the folios on which the various car sections are set forth.

SUBMARINE VERSUS SUBMERSIBLE BOATS.

By SIMON LAKE.

THE numerous fatal accidents to submarine boats during the past two years have led many people to the conclusion that the submarine is more dangerous to its navigators than to a possible foe.

Considerable criticism has been poured upon the heads of departments and those responsible for the construction of this class of vessel. Such criticism may or may not be justly due.

Submarine navigation in its modern aspect is comparatively a new art, and only by practical trials and the gradual elimination of weaknesses can a standard type be developed capable of safe control and yet able to inflict the greatest possible measure of injury upon the enemy.

The modern automobile torpedo is the primary reason for the existence of submarine vessels; and the ability of the submarine to intercept the foe with this proved weapon of destruction before the enemy can reach our harbours by gun-fire is sufficient warrant for its development apart from any other advantages that may follow in the train of its evolution.

Numerous trials with submarine vessels have shown that such boats can be run, in peace-time manœuvres, either under the water or in various stages of part submergence with a variable measure of success. It was only to be expected that there should be risks run and failures encountered with possibly serious consequences. Each one of the accidents, however, has brought substantial enlightenment, even though purchased in some cases at a grievous cost of life; and with this emphasis upon certain weaknesses it is now possible to predict the lines along which further progress in the art may be made with a reasonable assurance of immunity from dangerous mishap. Such have been the lessons to the technical student of the submarine.

An unfortunate condition of affairs has existed which has prevented a full understanding of the subject on the part of those responsible for the purchase of many of the submarine boats now extant. This has been the veil of secrecy cast about the submarine question by most of the inventors and builders of under-water craft. The inventors and builders have been compelled to keep secret many things which they have learned—perhaps by costly experimentation—at least until such time as patent protection could be secured. Many other features, the fruit of experience, but on which no such protection could be secured, have been kept secret for the soundest of business reasons. The writer has been no exception in these particulars. The fatal accidents of the past two years, however, have prompted him to make public the results of certain experiences and investigations, with a view to contributing, as far as lay in his power, to the prevention of disasters kindred to those that have so shocked the civilised world, and which, in the eyes of the general public, have cast discredit upon the art of submarine navigation.

Submarine vessels are broadly distinguished to-day by the two denominations of "submarine" and "submersible." The difference between these terms has not always been well defined. Boats of each type naturally are submarines in the common understanding of that word. The term "submersible" was first given to the Narval built in France in 1899. The earlier types of French boats were of the diving or plunging class originally, while the Narval was the first of the French boats primarily designed to submerge or be submerged bodily by the down-pull of hydroplanes, rather than to plunge or dive by the head, as is common in the diving type. It is in these distinctions that lie the most important differences among the present types of under-water boats.

France, to whom we are thus indebted for the term "submersible," is the only country in which the study and the development of submarine craft has been entirely under governmental auspices. There has been an entire absence of a spirit of commercialism in that investigation, and the conclusions of the French Admiralty to-day in favour of the "submersible" are based upon serious, painstaking, and practically exhaustive researches which have candidly considered submarine craft of all forms and types.

Russia, under the stress of war, being uncertain as to which was the type most to be desired, purchased boats of several sorts, in order to determine practically the class best fitted to meet the demands of actual conflict. None of the boats ordered were delivered in time to be factors during the period of hostilities; but the circumstances of war taught its lessons and showed the Russians the conditions that must be met by a successful submarine craft. Manœuvres and operations since undertaken in the light of these lessons by her active submarine flotillas have served to verify the conclusions of the French and to add Russia's decision in favour of the "submersible" as that term is understood in this article.

England and the United States have tried only one type—that of the diving order; and it is the diving submarine that has met with so many of the accidents—some of them fatal—during the past two years. Let us see if the reasons for these mishaps cannot be made clear.

The *sine quâ non* to the successful working of the diving boat is extreme sensitiveness in a fore-and-aft direction when submerged, or in other words, lack of longitudinal stability. Without this tenderness it is practically impossible, at the speeds so far attained, to control such a vessel when running submerged.

It is not necessary here to discuss either the administrative or the military aspects of this lack of longitudinal stability. The accidents that have occurred make a more direct and human appeal by emphasising the dangers faced by their crews even in times of peace.

The submerging or "submersible" boat requires no such hazardous limitation in the direction of safety in order to make her operatively a success. In the "submersible" it is possible to secure a far greater measure of longitudinal stability than is possible in the diving class. This greater longitudinal stability which may be secured in the "submersible" does not in any sense affect the speed and precision of action either in submerging or in maintaining a uniform degree of submergence when once under the surface. All that this may mean from a military or an administrative point of view has been thoroughly discussed elsewhere. Let us see, however, what are the physical conditions operating when a boat is submerged and against which those in control of a "diving submarine" must effect a balance by skill either in the form of deftness of handling or nicety of adjustment in one direction or another.

The loss of the British submarine A 8, therefore, may be taken as a case exemplifying in the plainest and most startling manner the dangers peculiar to the diving submarine. The testimony taken during the court martial showed that that boat when running in light condition had a normal reserve of buoyancy of about 16 tons. This had been reduced to six tons, and she was so trimmed that she was down 4 deg. by the stern at the time of the accident. The boat was running at a speed of 10 knots under her gasoline engines. It was further shown, by the testimony of Captain R. H. Bacon, R.N., that a moment to change trim of no less than 132 foot-tons would be required to bring the boat horizontal or on an even keel when trimmed in the condition described, and that a still greater moment to change trim would be required to bring the vessel down by the head so as to make her plunge. The practical proof that sufficient force was exerted in some manner to effect this very end was given by the sudden and disastrous manner in which that boat dived.

Both Sir William White and Captain Lees, R.N., have recorded their belief that the form of hull of the A 8, combined with her limited longitudinal stability, was in itself the prime reason for the sudden plunging of that vessel. Model experimental trials both in the United States and in Germany have only served to confirm that assumption. As far back as 1897 towing experiments with my boat Argonaut I., in her original form, made plain this tendency of the cigar-shaped hull, even when united with great fore-and-aft stability, to bury or to run under by the bows. The Argonaut I. was subsequently modified by the addition of a ship-shaped superstructure which eliminated completely the down pull at the bows previously so markedly present.

Without referring to the detailed results of my model tank experiments, the elemental difficulties can be shown in a graphic manner, with sufficient accuracy to demonstrate the forces at work tending to unbalance or upset a craft of the diving type, already more or less unstable in a fore-and-aft direction, and in which the reserve of buoyancy is needfully reduced to a dangerous degree in order that the boats may be made operative at moderate speeds.

The following diagrams will help to make the circumstances clear to the general reader. In Fig. 1 we have a

boat of the diving type running submerged in the usual manner—that is, with a trim of from two to four degrees by the head, in order to enable the vessel to remain under water. In the diagram, A represents the position of the centre of buoyancy, B the centre of gravity of the vessel, and C the horizontal rudder which is to overcome the righting moment of the short arm between A and B.

Experience and model experiments have shown that the down-pull at the bow in a cigar-shaped craft is much greater at or near the surface and at or close to the bottom; and it has been found that this down-pull changes with the depth below the surface, or the distance above the water-bed. To run "awash," therefore, it is necessary to trim by the stern, and, still further, to offset any tendency to plunge by setting the horizontal rudder a number of degrees "to rise," as was the case with the A 8.

To dive, additional water is admitted into what is called the forward trimming tank, the horizontal rudder C is set to "dive," and the vessel plunges under, head first, like a porpoise. Now, the trick in handling a diving boat is to allow her to reach a depth of several feet below the surface—where the down-pull at the bow is less—and then to catch her and hold her at that submergence by the continual manipulation of the horizontal rudder C.

The difficulties of the problem may be better understood by referring to Fig. 2, in which the conditions prevailing are diagrammatically likened to a balanced beam, for which the pivotal point A corresponds to the centre of buoyancy of the vessel, and the weight centred at B, acting as a short pendulum, corresponds to the weight of the vessel as a whole. B, then, is the one force tending to hold the beam horizontal. H is a float, representing the amount of reserve buoyancy statically in the craft when trimmed to run submerged, and bears to the total displacement of the boat the ratio of only about 1 to 560 in the case of vessels of the "A" class of 200 tons. It must be plain that this very small reserve of buoyancy can add practically nothing to the stability of the beam, which we assume is floating. F is a weight applied at relatively slight effect. It is, however, the one constant force, and the only one which prevents the craft from swinging like a pin wheel around its fulcrum at the centre of buoyancy A. The next disturbing influence is that of the down-pull at the bow, already noted, which varies according to the speed of the boat and the depth of submergence. The fifth element of disturbance is that of the sub-surface effects of wave motion, which gives a varying head, and, consequently, intermittent change of pressure or down thrust on different portions of the boat. The sixth force is one within the craft herself, and is the result of shifting weights in the form of surging water ballast, changes in position of the crew, or the transfer fore or aft of other masses.

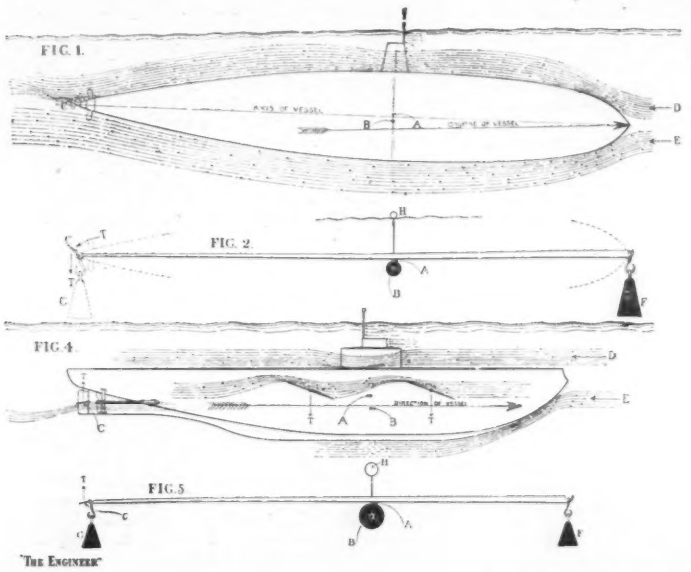
It will thus be seen that there are six disturbing forces to be taken into account, and of these four of them are continually fluctuating. These opposing forces must be harmonised by the manipulation of the horizontal rudder C, which, by the exercise of great skill and control and within prescribed limits, it has been found possible to do under certain chosen conditions. A moment's inattention, however, on the part of the helmsman or the failure of the horizontal rudder to respond with sufficient quickness may lead at once to loss of control, and the vessel will either break for the surface and broach or plunge toward the bottom, with the risk of disaster under the impulse of her driving engines and the rapidly increasing inclination of her bow. If the engines can be stopped before the vessel has struck the bottom, then the two constant forces—those of the righting moment of the pendulum A-B and that of the reserve buoyancy—will combine to bring the vessel back to her normal horizontal position and to draw her again to the surface. It should be plain from this what must be the task of the operator at the diving rudder and to what degree his skill must be developed to meet the conditions thus confronting him even in time of peace and amid surroundings and circumstances carefully chosen. How much greater then must be his task when operating amid the environments of warfare and under the nervous stress of actual conflict! Sub-Lieutenant Godfrey Herbert, one of the officers aboard the A4 when she sank, testified—as stated in the *Naval and Military Record*:—"The boat sank to a depth of 90ft. before starting to rise. During this time water was coming down the ventilator with considerable force, which increased as the depth got greater. In about a minute the lights went out, and it was with great difficulty that the captain's order to put the 25 horse-power pump on to the fore bilge was attempted. Just before the lights went out the boat had an inclination by the bow of 40 deg., and all small gear and the cloth covering the batteries were washed forward. . . . The gauge was shown at 90ft. It could not show more." From an editorial in the same paper we find the following:—"They are liable, says Sir William White, to unexpected dives, and this again is confirmed in the case of the A4 by the testimony of the coxswain."

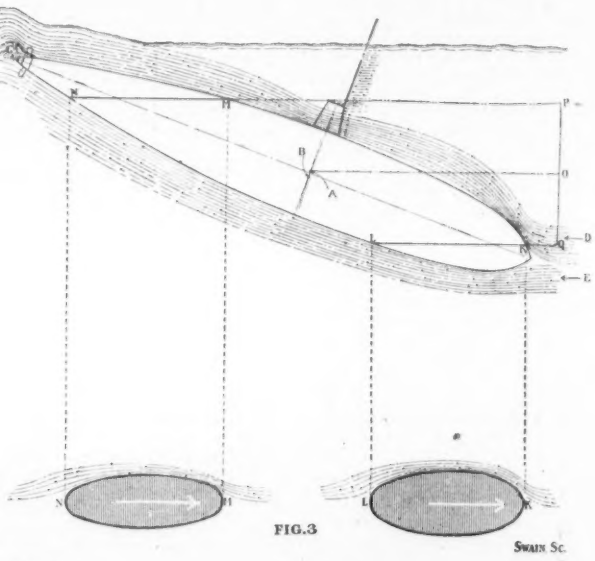
Fig. 3 represents a boat of the diving type and of the "A" class, submerged and inclined at just half the angle assumed by the A 4 when she sank. It will be seen from this diagram how considerably the down-pull at the bow is augmented by every change of trim on the part of the cigar-shaped craft; and it is not difficult to understand how a very rapid increase of inclination may render less effective the counterbalancing factor of the horizontal rudder C. This has been borne out by numerous official reports.

In the case of Fig. 3, it is assumed that the boat has started in the condition primarily required—with trim by the head—as indicated in Fig. 1, and that the vessel was then moving forward in a plane parallel to the surface. By reason of some of the causes or forces heretofore described, the craft now takes a further inclination or dip by the bow. Fig. 3 shows graphically what occurs when the momentum of the vessel tends to maintain her on her forward course in a plane parallel to the surface. The stream lines, instead of parting fairly on each side of the bow, come with greater force against the forward upper half of the vessel, and impart, by reason of this, a strong downward thrust at that point, while the supporting resistance on the under side of the hull at the bow is considerably lessened. Consequently, the balance is destroyed and a very much larger angle of the horizontal rudder C is called for. There is, of course, a limit to the effectiveness of the horizontal rudder C. A horizontal section drawn through L-K, and another drawn through M-N, each equally distant above and below the centre of buoyancy when the boat is inclined as shown in Fig. 3, give the relative areas of resistance, and illustrate how much more rapidly the forward or lower area increases than the after or upper area. It will be seen from these sections how much more difficult the lower one is to move forward through the water than the after or upper section. This, of course, is due to the very bluff character of the lower section and its greater tendency to produce eddying, back pressures, &c., when driven at a considerable speed. Therefore, the condition becomes as follows:—The vessel moves forward first in a horizontal plane, and then for some of the reasons previously stated additional inclination occurs; resistance to progress of that part of the vessel below the swinging point O—*i.e.*, a line intersecting the centre of buoyancy—increases and retards the bow, while the momentum of the craft carries the upper and less resisting section—now the tail-end or after-body of the boat—forward: any shifting weights, providing the angle has become great enough, would move forward, as in the case of the A4; the horizontal rudder even when given its maximum angle of rise proves ineffective, and the boat continues to dive with a rapidly increasing inclination unless the machinery is stopped and the vessel's momentum arrested. If the vessel during this interval has not been brought to a standstill by the bottom she may continue to plunge to a depth where the pressure may prove sufficient to cause her collapse.

Fig. 4 illustrates a "submersible" of the latest type, which will be explained in connection with Diagram 5, so that a direct comparison may be drawn with the working principles of the diving boat, as shown in Figs. 1, 2, and 3.

In Fig. 4 the "submersible" is shown running on a level keel—the position normal to boats of this type—instead of being several degrees down by the bow, as is





THE STABILITY OF SUBMARINE BOATS

the short arm of the beam, and represents the downward pull at the bow graphically, but not relatively, because this weight or force is a continually changing quantity, which must be as continually checked or counterbalanced by the force of the stream lines impinging against the horizontal rudder C—in the direction of T^1—which must equal, in effect, a counterbalancing weight placed at G and acting in the direction of T. With expert steersmen, and by fine adjustments of water ballast, a certain measure of success has been won after experimenting with vessels of this particular type for a period of half a century. But this success is at the expense of constant vigilance, and with so many restrictions, that under some conditions it is still impossible or dangerous to navigate submerged in this manner.

Again referring to Fig. 1, it will be seen that when the boat once reaches the position shown, she is running with a slight downward inclination by the bow, which is required to balance the upward pull of the reserve buoyancy of the vessel. In smooth water and with the vessel running at an angle of only a few degrees, the stream lines D and E are parted at the bow easily and sweep around the vessel in an approximately uniform manner. In this condition the boat moves forward in a plane parallel to the surface of the water, but not with the axis of the craft parallel to the surface. In other words, the boat does not follow the true direction of her axis, but moves forward at an angle, and her course is a mean between two opposing forces:—First, that of buoyancy, which is continually tending to bring the vessel to the surface; and, secondly, that force due to the downward thrust of the screws in line of the axis of the boat. These opposing forces can be balanced only by exceptional skill on the part of the man at the diving rudder, otherwise the maintenance of a uniform depth in a diving boat becomes impossible.

In addition to the two forces just mentioned, there are others which tend to destroy the trim of the boat. The first of these is the righting moment of the pendulum A-B, which tends to bring the vessel on an even keel. This may be considered as a constant force, but for the shortness of its arm it can have, of necessity, but a necessary with the "diving" type. The reason why it is thus possible to run the "submersible" on an even keel is as follows:—It will be observed in the first place that the hull is quite different in form. This raises the centre of buoyancy to a point much higher than it is possible to do in the regulation cigar-shaped craft of the "diving" type. The vessel is also provided with a heavy keel, which lowers the centre of gravity. Therefore, the arm of the pendulum A-B becomes longer and its righting moment correspondingly greater. This is a most important feature, as it contributes directly to securing the greatest possible measure of longitudinal stability under the circumstances. As the boat does not need to be inclined to submerge her, there is no limit—by reason of operative requirements—to the longitudinal stability that may be given the submersible; and in practice it is desirable, of course, to have the longitudinal stability as great as the form of hull and the arrangement of weights will permit.

To run "awash," or submerged, the vessel is trimmed by adding water ballast until only the desired amount of reserve buoyancy remains which will ensure the boat resting on an even keel, with her conning tower in an awash condition in relation to the normal surface. In other words, the beam or balance represented by Fig. 5 is brought to a horizontal position by adding fixed weights at both ends, so that G and F are equal. In this condition the "submersible" can be run without risk of, or impulse toward, a sudden dive.

The official reports and the testimony given during the court-martial following upon the loss of the A8 confirm the belief that it is either impossible or dangerous to run "diving" boats upon the surface on a level keel, even when retaining a very considerable reserve of buoyancy. This hazard is primarily due to the down-pull at the bow, characteristic of the cigar-shaped form of hull, and lacking longitudinal stability of vessels of the "diving" type. With the "submersible" of the type illustrated here there are none of the tendencies to dive so characteristic of the other order of boat under these circumstances. The reasons for this are the great longitudinal stability and the structural form, which completely off-

COMM. ERASMO MARI'S FACTORY FOR THE PRODUCTION OF SILKWORM EGGS

(For description see page 643)

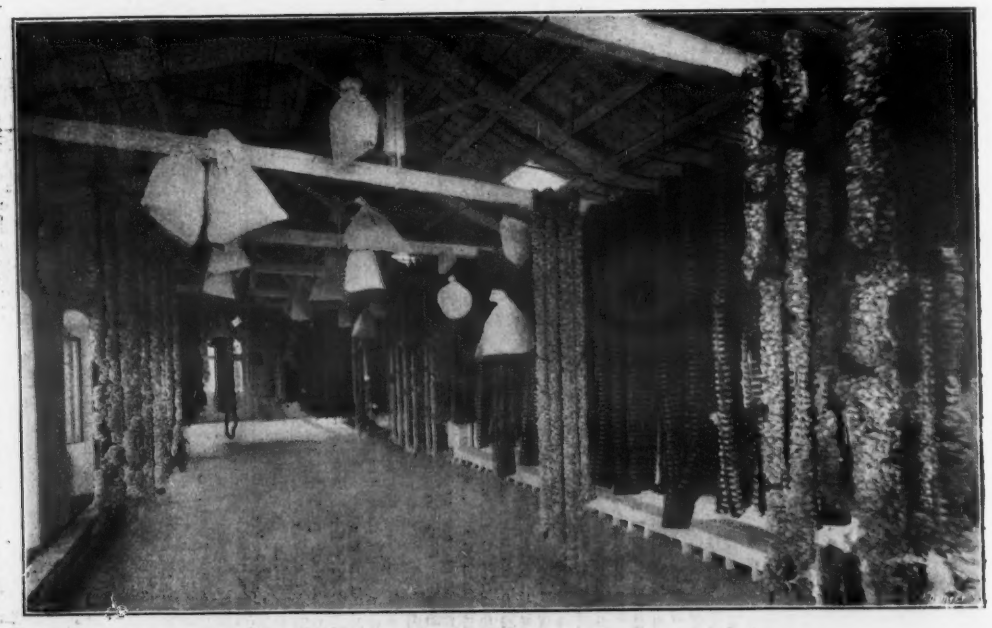


Fig. 3—CELLULAR SEGREGATION OF SILKWORM EGGS

Fig. 4—CRUSHING DEAD MOTHS FOR FIRST SELECTION

Fig. 5—MICROSCOPICAL EXAMINATION OF SILK MOTHS

Fig. 6—FINAL EXAMINATION OF SILK MOTHS

set the development of a downward pull. The vessel being in the "awash" condition just described is given headway, and it is soon noticed that there is a slight tendency to change trim by rising at the bow—due to the thrust against the large conning-tower—and this is at once corrected by a permanent angle of the horizontal rudder C intended for this particular purpose. It will be observed, of course, that this horizontal rudder is placed aft, as in the "diving" boats, but it is used for the very opposite purpose of keeping the vessel in a horizontal position, rather than to cause her to take a dip or plunge, as is the case with the "diving" type. A downset of the horizontal rudder of only two or three degrees is usually sufficient to balance the tendency of the bow to rise in boats of the "submersible" type herein illustrated. A level keel being thus secured, the angle of the horizontal rudder remains constant for a given speed.

The "submersible," still running in the "awash" condition, but ready for instant submergence, is quickly brought completely under the water—without change of trim—by depressing the forward ends of the hydroplanes. This causes the stream lines at the side of the boat to impinge against the upper surfaces of the hydroplane and to give a resultant downward thrust, as indicated by T T, in Fig. 4. The hydroplanes, being four or more in number, and symmetrically disposed in regard to the centre of buoyancy or fulcrum, the thrust against their upper faces causes the boat to sink on an even keel. It will be observed that the stream lines at the bow are not affected in the same manner as those at the bow of the "diving" boat of cigar-shaped form. There are none of the disturbing eddies developed peculiar to the spindle-shaped hull; and the vessel moves forward along the line of least resistance instead of at an angle. The thrust of the screws or the momentum of the vessel, when the machinery is stopped, impel her in the direction of her major axis, which is in the plane of the course desired.

When the vessel has reached the depth desired, the hydroplanes are brought back to an angle which will yield just pressure enough to counterbalance the upward pull of the reserve buoyancy statically in the craft, and indicated by H. Because of the buoyant character of the superstructure and the greatly increased buoyant moment of the conning-tower in vessels of this class, the righting effect of this force is very much greater than can possibly be the case with boats of the "diving" type. The reserve buoyancy is the only force which it is necessary to counteract in "submersibles" of the type under discussion; and this force is a constant one, and so easily balanced or neutralised that the writer has frequently left the controlling mechanism of the hydroplanes—situated in the conning-tower—and has gone below into the engine-room for periods of several minutes at a time, and has returned to the conning-tower and found the boat running still at substantially the same depth as that at the instant of his departure. The reason for this is the fact that in the "submersible" we thus do away with four fluctuating forces which are inherent or peculiar to boats of the "diving" type and spindle form of hull.

The practical results thus secured by the "submersible" are:—

(1) Safety in submerged control.

(2) Facility in handling that calls for no special training or rare dexterity on the part of a single member of the crew.

(3) Easy maintenance of a uniform depth on an even keel in waters of variable depths, thus making it safe and practicable to operate either in deep or shallow waters.

(4) The removal of restraint to free movement on the part of the crew in the very fullest discharge of their duties.

(5) By preserving an even keel, ensuring the effective operating of the observing instrument the moment it appears above the surface, and thus affording that measure of safety and efficiency following in the train of rapid observation of the entire horizon.

(6) The ability to discharge torpedoes with the vessel always on an even keel, thus ensuring the maximum probability of making a successful target.

These advantages have appealed with convincing force to both the French and the Russians, who have examined and tested exhaustively these rival methods of operating, and the practical reasons for this decision are not to be denied while the records of so many serious accidents to "diving" boats in the hands of skilled crews give us cause for pause and question.

LAUNCH OF H.M.S. AGAMEMNON.

THE first-class battleship Agamemnon was launched from William Beardmore and Co.'s Naval Construction Works at Dalmuir on the 23rd inst. With the sister ship Lord Nelson, being built by the Palmer Company, at Jarrow-on-Tyne, the Agamemnon is the first battleship designed by Sir Philip Watts since his appointment as Director of Naval Construction. The Agamemnon is shorter than the ships of the King Edward class, being 410ft. in length, as compared with 425ft., but the beam is 18in. greater, being 79ft. 6in. These dimensions are more suitable for existing docks than those of her predecessors, as well as of the Dreadnought, a somewhat later design of Sir Philip Watts, built with great celerity, and now being fitted out at Portsmouth. At 27ft. draught the Agamemnon will displace 16,500 tons. The speed is to be 18 knots, the twin engines, supplied with steam from fifteen Yarrow water-tube boilers, giving 16,750 indicated horse-power.

In many of her details, as well as in the broad principles of design, especially as regards her armament, the Agamemnon embodies departures from previous practice, and marks the intermediate stage between the King Edward and the Dreadnought classes. The former is equipped with four 12in. and four 9·2in. guns on the upper deck, and ten 6in. guns, most of them on the main deck. The Dreadnought has ten 12in. guns, while the Agamemnon has four 12in. guns and ten 9·2in. guns, all above the upper deck. The guns have thus a higher platform, being about 9ft. further above the water-line than many of the guns in earlier ships of the line. The guns, too, are more concentrated in the centre of the length of the ship, and over 30ft. above the water-line, so that they have a great command of the water around the ship on all sides, and to this extent are better able to check torpedo-boat attack. The large guns are all covered in, excepting the muzzles, and they have not only a great height of platform, but considerable arc of training. The 12in. guns are mounted in pairs in barbettes fore and aft; while eight of the 9·2in. guns are in twin barbettes, the remaining two being in single-gun barbettes in the centre of the broadside. Four 12in. and 9·2in. guns constitute the broadside fire, while ahead or astern two 12in. and four 9·2in. guns can be used. In addition to these weapons, there are thirteen 12-pounder quick-firers, twenty-three 3-pounders, and two Maxim guns, with two guns for boat or field use. The ship has five submerged tubes for firing torpedoes, two on each broadside and one at the stern.

In protection, too, the Agamemnon has more powerful provision than preceding ships, and in this respect is probably quite equal to the Dreadnought. The water-line belt amidships is 12in. in thickness, reduced towards the stern to 4in., and towards the bow to 6in. Above this, in the central part of the ship, the broadside to the upper deck is of 8in. armour, and the thwartship bulkheads to protect against raking fire from before as well as from abaft the beam are of 12in. in thickness. The same thickness of armour is also used for the conning tower.

The Agamemnon, whose hull has been built on very fine lines, will be propelled by twin screws. The bow has the usual ram formation, but the stern differs from earlier ships, representing somewhat the type of the Elswick model, with the balanced rudder partly suspended rather than supported at the bottom. This, it is claimed, improves the turning movement of the ship. A deep bilge keel extends for almost two-thirds the length amidships. The machinery is of the usual naval type, with four cylinders for each set, working on the three stage compound system. The high-pressure cylinder in each set, taking steam direct from the boilers, is 32¾in. diameter, the next in the series is 53¾in. diameter, and from this latter the steam passes to two low-pressure cylinders, each 60in. in diameter, the stroke in all cases being 48in. The engines will develop their full power of 16,750 indicated horse-power with 120 revolutions, equal to a piston speed of 960ft. per minute. These engines have been constructed by Hawthorn, Leslie and Co., of Newcastle-on-Tyne, the extensive new works of William Beardmore and Co. not being in a position to justify the firm undertaking the contract, lest they should not be able to complete it within the stipulated time. The normal coal load of the vessel will be 900 tons, but space has been arranged for carrying 2500 tons, which will give the Agamemnon a very considerable range of action.

Quite apart from the fact that the Agamemnon is so notable an example of the modern trend of naval development, and the largest warship yet built on the banks of the Clyde, the launch was of quite exceptional interest. This was not so much on account of the heavy weight to be transferred to the water—the launching weight being between 6500 and 7000 tons—considerably less than half that of the Lusitania, sent off the stocks of the neighbouring establishment at Clydebank the other day—but because the event was practically the opening ceremony of what is, or has every promise of becoming, one of the largest and best equipped naval establishments in the country. Platforms at the bow and alongside the vessel were crowded with spectators, the guests of the firm, and the yard generally was occupied by a vast concourse of workpeople and local residents. Amongst the guests on the bow platform were the Earl and Countess of Aberdeen, the latter of whom named the vessel, while the religious service, usual at launches of ships for the British Navy, was conducted by the Rev. William Swan, minister of Old Kirkpatrick parish.

Built on a line of declivity of $\frac{7}{8}$in. per foot the Agamemnon's bottom was unusually high above ground level, the height of the cross timbers underneath the standing ways, about the forward part of hull, being quite 15ft. or 16ft. While this entailed an unusual amount of timber support, the advantages of the extra head-room for workmen, and for the passage of material underneath the structure, far outweighed any saving in timber make-up, which only a usual height of keel or bilge blocks might have conferred. The thoroughness and substantiality in evidence here also marked the launching make-up, both as regards standing and sliding ways, and the cradle poppets or uprights. The heads of the latter abutted against a steel shelf securely fixed to the shell forward and to the under side of propeller bosses aft, the shelf on each side, for the whole length almost, being tied by broad belts of plating and wood packing crossed under the vessel's forefoot, forming a strong sling in which the vessel was supported. There were two releasing triggers, of special design, interposed between the standing and sliding ways on each side near the fore end of the cradle, and at the proper moment these were instantaneously and simultaneously disengaged by an electric current. A powerful hydraulic ram was stationed at the fore end of the sliding ways on each side, but these did not require to be put into operation. About eight minutes past one o'clock the last of the blocks supporting the vessel at the bilges was knocked away, and shortly thereafter the christening bottle was sent against the ram of the vessel by the turn of a miniature steering wheel on the ceremonial platform by Lady Aberdeen. Almost instantly, but very gradually at first, the huge vessel began to move. Until mid-distance was reached motion was slow, but the vessel rapidly gathered way thereafter and entered the water with remarkable smoothness, only a suggestion of frictional heat and smoke from the ways occurring just when the vessel was near the dipping stage. One minute fifty-one seconds after the release the vessel was completely water-borne, with singularly little disturbance on shore or afloat, the checking by three wire check-ropes attached to the vessel's sides and to piles of chain-cable on the ground alongside the berth—as is now the arrangement most in favour—being prompt and effective. Tugs in readiness took the Agamemnon in tow, and she was in a very short time safely berthed in the company's tidal fitting-out basin.

At the luncheon provided for the large company of specially invited guests, Mr. Wm. Beardmore, the chairman, in proposing "Success to the Agamemnon and the Health of Lady Aberdeen," said that there was a double interest in the launch that had taken place that day. The Agamemnon was the first ship designed by Sir Philip Watts, the present Director of Naval Construction, and not only did she differ from the ships designed by Sir William White, but also from ships designed by Sir Philip Watts a few months later. The ships which composed the fleet to-day were very inferior in armament to those which were now being built. The ships of the Majestic class, for instance, had only four 12in. guns. The remainder of their weapons were 6in. and 7in. guns. The Dreadnought had ten 12in. guns. This showed the enormous difference there was between the Dreadnought and the ships of which the fleet was at present composed. Not only so, but gun manufacturers had made so many improvements in the type of guns that a new 12in. gun was to-day about 50 per cent. more effective than the 12in. guns at present in the fleet. Were the Dreadnought and the Majestic to face one another, the Dreadnought, he ventured to think, would put the Majestic out of action in a very short time. The range of the guns was much greater in the later type of vessel. He had, indeed, heard it stated that the Dreadnought was equal to any three battleships now in the British Navy. Comparing the Agamemnon with the Dreadnought, the difference was mainly in the armament. The former had four 12-inch guns and ten 9-inch guns. It remained to be seen which design would prove the more effective, but he thought that probably there would in future ships be a combination of the best points of both. Not only had there been a great improvement in armour. The 8in. armour of to-day, he believed, was more than equal to the 12in. armour of four years ago. These things made an enormous difference in the power of the fleet. It simply meant that as things were now progressing, the fleet became obsolete in four or five years. This was a serious matter for the taxpayer, who had to keep up the fleet, but he was afraid it was true. The second point of interest to which he wished to refer was the fact that that launch was practically the opening ceremony of their new yard, which he ventured to think was one of the best equipped naval establishments in the country. The river frontage was over a mile in length, the dock was 1000ft. in length, and 350ft. in breadth, and the workshops were all of the largest dimensions, and contained the most modern and up-to-date tools. The yard was also unique in this respect, that it was the first establishment of such proportions in which steam as a motive power had been entirely discarded. All the machines were driven by electric motors, and those motors were worked by electricity generated by internal combustion gas engines. There was not a steam boiler in the whole place. In this he thought they might claim that they had done something wholly new. The gas they used for power purposes they first of all chemically treated, so as to extract from it the nitrogen, which was of no use for heating purposes, but was of great value for fertilising purposes. The result was that by taking from the gas that nitrogen and forming it into sulphate of ammonia, they found that when they came to square their accounts that their coal bill was entirely paid by the money received for sulphate of ammonia. In concluding, and speaking on behalf of the firm, he had pleasure in presenting Lady Aberdeen with a silver model of a full-rigged antique man-of-war.

Mr. Edmund Sharer, in responding to the toast of "The Builders," proposed by Lord Aberdeen, said that he did not think any other shipbuilding yard in this country ever had the honour of commencing its career by building a battleship for the British Government. The Agamemnon was the first battleship to be launched on the Clyde all the armour of which was manufactured by the builders themselves. She was also the first battleship ever built without the use of steam. She was the first of her class to be launched, while she had been brought to the launching stage in nine months and twenty working days. In speed of construction the credit lay with the Dreadnought, but if Beardmore's got a repeat order they would beat the Dreadnought's record. He wished to express the indebtedness of the firm to the Admiralty officials, and to their own workmen for the hearty support they had all given them in the construction of the vessel.

ROYAL METEOROLOGICAL SOCIETY.—The final meeting of the session was held on Wednesday afternoon, the 20th inst., at the Society's Rooms, 70, Victoria-street, Westminster, Mr. Richard Bentley, F.S.A., president, in the chair. Mr. F. J. Brodie read a paper on "The Mean Prevalence of Thunderstorms in Various Parts of the British Islands during the Twenty-five Years 1881-1905." The author gave the mean number of days on which thunderstorms or thunder only occurred in each month, each season, and in each year at fifty-three stations situated in various parts of the United Kingdom. July, he said, was the month with the largest number of thunderstorms over Great Britain as a whole, and August at some places in the North of Scotland and North-west of England, while June is the stormiest month at nearly all the Irish stations. Mr. W. H. Dines communicated a paper on a "Typical Squall at Oxshott, May 25th, 1906."

ROYAL AGRICULTURAL SHOW.

No. I.

AFTER a break in the itinerary show system extending over three years, and a disastrous experience at Park Royal, the Royal Agricultural Society has this year resorted again to its former practice, and is holding its sixty-seventh annual exhibition on a plot of land known as Osmaston Park, Derby, lent by the Midland Railway Company, and as far as can be gathered the prospects are distinctly brighter than in recent years. The entries show a decided improvement over those of late years, and particularly upon the entries received at the London shows. In the implement section the number of stands at Derby is 424 compared with 289, 350, 456, 340, 358, 412, 395 in the seven preceding years, and 377 at the last Derby Show in 1881. The increase in the live stock entries is equally satisfactory, demonstrating—if demonstration were necessary—the folly of fixing on a permanent showground near London. Although not so large as some previous showyards, the present ground, covering 84 acres, is ample, and obviates much unnecessary perambulation on the part of visitors as regards the implement section at any rate. The usual method of placing the machinery exhibits between the main entrance gate and the live stock exhibits has been followed, as it ensures visitors passing by the machinery, which is thus brought under the observation of all. The special features of advantage that have been introduced are that, instead of an exceptionally wide central avenue along which the majority of visitors passed, the fan-shaped setting out of the ranges of shedding distributes the public more widely. Much of the improvement has been rendered practicable because the large open space near the entrance, which has been a feature of recent shows, is not provided; the space being occupied by a deep block of machinery in motion on one side and the natural shape of the ground on the other; and the central part being occupied by two blocks or stands.

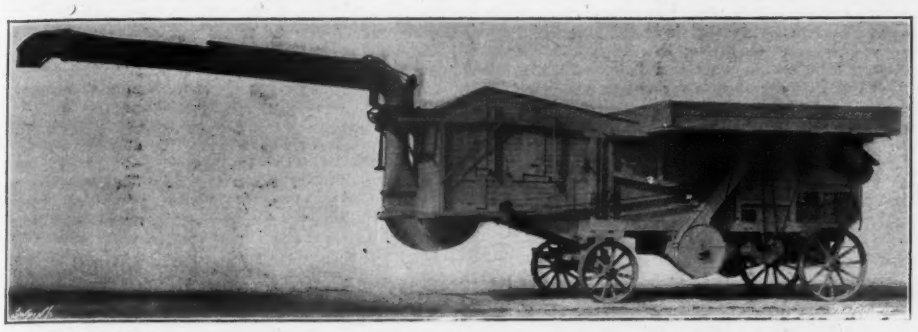


Fig. 1—FOSTER'S THRASHING MACHINE AND WIND STACKER

It was a happy idea on the part of the Council in restarting the county shows to hold a competition of gas engines and suction gas plants, as the entries have amply proved. At the present time there is probably no problem in mechanical engineering receiving more attention than this economical method of producing power. We have elsewhere dealt in detail with the twelve systems entered for the competition which has now concluded, and for description of these plants we must refer our readers to the present and last two issues of THE ENGINEER. The result of the competition was announced in the showyard on Wednesday as follows;—First prize, gold medal, the National Gas Engine Company, Limited, Ashton-under-Lyne, for a 20 brake horse-power National gas engine and suction gas plant; second prize, silver medal, Crossley Brothers, Limited, Openshaw, for a 15 brake horse-power gas engine and regenerative suction gas plant. We are authorised to state that in making the awards economy was not the only, nor, indeed, the chief point taken into consideration by the judges. The trials have been extremely close, and at the finish there was little to choose between several of the competitors, so that, although defeated on this occasion, the unsuccessful makers have nothing to be ashamed of.

Besides the suction gas plants which were entered for the trials, there were others exhibited which call for attention while on the subject. Ruston, Proctor and Co., Limited, Lincoln, have on view a 30 horse-power plant which embodies novel features. In this there is no water seal, and a three-way cock is provided for opening the generator to the atmosphere, and shutting the passage to the scrubber when closing down at night, for instance. The drain box is also closed in, so that there can be no smell on this score, and both the producer and the scrubber are arranged so that they can be disposed in different relative positions, according to circumstances. It is stated that this plant can start up on full load in twenty minutes, and the cost of the operation is equal to ·749 lb. of fuel per horse-power per hour.

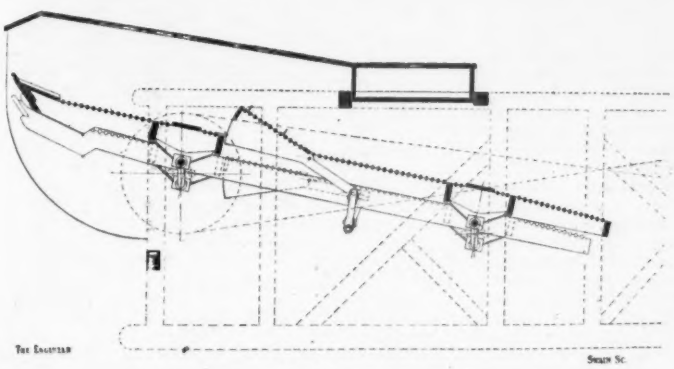


Fig. 2—CLAYTON AND SHUTTLEWORTH'S SHAKER

As regards purely agricultural implements, the show has been the means of bringing to public attention many new or improved appliances. In this respect, attention may be called to the list of so-called "new implements" in the catalogue which are entered for the Society's silver medals. This list contains nearly sixty entries, but a microscopical investigation of some of the claims to newness would fail to show their novel features. The Council would do well to exercise more discrimination in the acceptance of entries under this heading.

One of the most prominent features of the show is the increase in the number of light steam tractors compared with previous shows. These are exhibited by Aveling and Porter, Burrell and Sons, Clayton and Shuttleworth, Foster's, Garrett's, Ruston and Proctor, and Wallis and Steevens, while the steam wagon exhibitors include Jesse Ellis and Co., Foden's, Hindley's, Mann's, the Yorkshire Steam Wagon Company, and Robey and Co., Limited. The last-named firm are newcomers in this department, and show for the first time a steam wagon with many interesting features, to which we shall refer in a later issue. Now-a-days improvements in thrashing machines partake of only a minor character, but Clayton and Shuttleworth's have introduced an improvement which needs mention. It is connected with the shaking mechanism, and it is intended practically to double the vertical movement, or shaking, of the straw in its passage from the drum, as shown in the accompanying sketch, Fig. 2, and thus make it impossible for any grain to pass over the boxes with the straw. The device is said to have been severely tested, and has been proved a success throughout lengthy experiments. The thrashing machine is also fitted with a new adjustable cavings riddle, which, by turning a thumb screw, can be varied to suit any class of grain. The loss of time and trouble involved in changing the ordinary perforated riddles is thus avoided, and the arrangement throughout is exceedingly advantageous. Another great improvement is found in the new patented rotary corn screen, the wires of which, still retaining the same special section as before, are now grooved on the inside, in order to admit of the spiral adjusting springs being more tightly and compactly bound to them. The new screen has been greatly strengthened and made still more efficient as the result of this alteration.

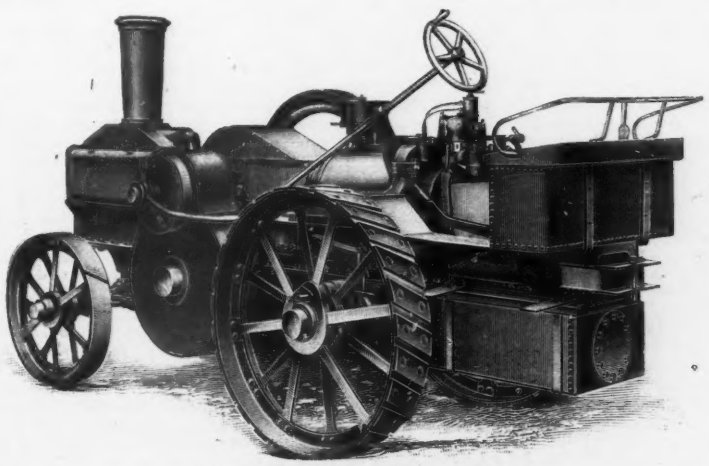


Fig. 3—PETTER'S OIL ENGINE TRACTOR

William Foster and Co., Limited, Lincoln, exhibit a 5ft. thrashing machine for the South American market, which is provided with a wind stacker, as shown in Fig. 1. The makers claim that this device will be a much-appreciated feature in countries where labour is scarce, as one man, by its aid, can build a stack without the assistance of several other labourers. The standard type of machine is used, and under the shaker end a hopper with a powerful fan is arranged. This fan delivers the straw through a long sheet iron tube. The end of the tube has a hood and deflector, by means of which the direction of the straw can be controlled. A turn-table is arranged on the top framework, on which the tube can oscillate automatically from side to side at a slow speed. In addition to this the tube can be extended or telescoped, and raised and lowered. The weight of the attachment does not make any material difference to the travelling of the machine. In this firm's steam tractor a feed-water heater has been added, and is said appreciably to reduce the fuel consumption, and as part of the exhaust steam is utilised for heating the water, ultimately exhausting into a receiver box in the ashpan, there is less exhaust steam visible from the chimney.

James B. Petter and Sons, Limited, Yeovil, amongst other machines, show a tractor in which the motive power is supplied by a horizontal single-cylinder petroleum engine capable of giving 25 brake horse-power at 300 revolutions. Paraffin is vaporised in a metal bulb which forms part of the compression space. This bulb is not water-jacketed, and the igniting lamp, which is fed by pressure from its own tank, plays against its exterior surface to provide the initial explosive charge. The crank shaft is placed transversely across the frame. A segmental expanding clutch is keyed to a projection of the shaft, and by means of intermediate gearing transmits motion to a lay shaft, from which again it is transmitted to the live back axle by means of a single roller chain. The engine has a fly-wheel 42in. diameter, weighing 6 cwt. The engine is cooled by water circulation, a belt-driven rotary pump and a special type of radiator being used. The vehicle has two speed gears, weighs 3 tons 10 cwt., and is convertible into a road roller. It is fitted with a driving pulley, and if desired may be used as a portable engine for driving thrashing machinery or other farm implements. It is shown in Fig. 3.

A new farm implement, or combination of two implements, worthy of mention is shown by J. B. Edlington and Co., Limited, Gainsborough, and is a combination of mower and swathe turner. This has been designed to meet the objection often raised that the way in which hay is now made is wasteful, because the cut end is left on the ground, and so allows most of the juices to run down the stems. It is contended that the reason why hay should be turned immediately is that the sun seals up the cut end and so prevents the juices leaving the stems, thus preserving all the feeding properties—albuminoids, amides, carbo-hydrates, &c.—which such juices contain. The combination is simple and effective.

The show opened on Wednesday last and closes to-morrow (Saturday). The attendance on the first day was greatly in excess of the attendances on the first days in recent years, notwithstanding the unpropitious state of the weather. We shall give further particulars of the more important exhibits next week.

LONDON ELECTRIC SUPPLY.

AT the moment of going to press we learn that the Hybrid Committee appointed to consider the London County Council Electric Supply Bill have come to the unanimous conclusion that they must report to the House that the preamble of the Bill has not been proved. The fact that this decision was unexpected will only add to the satisfaction of those who regard with misgiving the attempt to municipalise electric supply, and with grave disapproval the huge expenditure to which London would have been committed had the Bill been passed. An exhaustive report on the whole question of the supply of electricity in bulk in the metropolis has been drawn up by the members of the Committee, and will in due course be presented to the House of Commons. Its publication will be awaited with the liveliest interest. In the meantime we hasten to congratulate the Committee on its decision and those who resisted the Bill, promoters, counsel, and witnesses alike, on the success of their endeavours.

IT has been decided to reconstruct the Chinese Eastern Railway in Manchuria, and a wider gauge will probably supersede that favoured by Russia. During the war Japan laid a light railway on the Russian road between Sinmintun and Mukden. The railway will be sold to China, and then reconstructed with capital jointly provided by China and Japan. The traffic will be carried on in the name of the Chinese Government, but the working staff will mainly consist of Japanese. On the expiration of eighteen years, the Chinese Government is to repay the Japanese portion of the cost of reconstruction and acquire complete control of the railway. Meanwhile, Japan will hold the railway and its receipts as security.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

OUR readers are already acquainted with the programme arranged by the Institution of Electrical Engineers for the entertainment of the members of kindred institutions from Canada, France, Germany, Italy, Switzerland, and the United States, who are now visiting this country. It includes visits to many of our principal cities, and to the places of most interest, either from a scientific, historical, or merely amusing point of view, in England and Scotland, and very wisely, we think, there is no formal meeting with the reading and discussing of papers.

On Monday the members assisted at the opening of the new electro-technical laboratories of the National Physical Laboratory by the Right Hon. R. B. Haldane, and were subsequently entertained by the director and his staff, and invited to inspect the other sections of the laboratory.

The new laboratory is an extension of the engineering laboratory, and is, therefore, in a building apart from Bushey House. It has just been completed by Messrs. Mowlem, who have done the work at cost price from designs by Messrs. Molt and May, who have generously given their services. The main portion of the new laboratory consists of a top lighted shed, 120ft. by 50ft., divided into two bays 25ft. wide each, one of which is again divided by a transverse partition. One of the small rooms so formed is intended for resistance experiments, and has a glass ceiling, and the lights above are glazed with a double thickness of glass; the space between the ceiling and the roof will be heated, and it is hoped thus to maintain the temperature fairly uniform. Artificial ventilation is provided. The entering air passes over steam-pipes, by which its temperature can be regulated. The other half of the same bay is designed for heavy test work. Two bed-plates are fixed in the floor, and arrangements are made for a travelling crane traversing the the length of the room. The long bay to the north of the building is for most of the ordinary test work. At the extreme west end is the main switchboard, receiving power from the dynamo room and also from the mains of the supply company, and distributing it to the machines in the building and also to the batteries. Adjacent to this will be the machines placed on a concrete platform isolated from the rest of the building. The rest of the bay is assigned to experimental work, the western portion being reserved for alternating-current experiments, and the eastern portion for direct current. The batteries are on the top floor of an annexe to the east of the main block, above the rooms reserved for photometry; thus the direct-current work requiring heavy currents will go on in the extreme eastern portion of the main bay.

The photometric department to the east of the main block occupies a space of 100ft. by 20ft., and is arranged mainly on two floors; at the south end of the block, however, there is a space extending from the ground to the roof, designed for large apparatus, or for experiments requiring a range of height. Convenient galleries enable access to be obtained to apparatus at various levels. Of the other two rooms on the ground floor one is arranged for life tests on lamps, the other for general experimental work; the photometer rooms proper are on the first floor, that to the north being for standard work, and that to the south for ordinary tests and experiments. Tracks are laid in the floor along which the photometers can be moved; one of these is the full length of the building, and gives a range of about 80ft. for work with high candle-power lamps.

The visitors, after the formal opening ceremony, visited the other rooms, where the use of the various pieces of apparatus were demonstrated by the gentlemen in charge of them. In the engineering laboratory the testing machines attracted a great deal of attention. The first was the alternating stress machine, which has now been in use for some time, and the second is, we believe, of much later date. It is a many blow impact machine of a novel kind. The specimen is a long cylinder about $\frac{1}{2}$in. diameter, carried by supports some 4in. or 5in. apart. At its centre a shallow and narrow groove is turned. The diameter at the bottom of the groove is carefully gauged. Immediately above the centre of the test piece is a slide containing a metal cylinder, weighing 4$\frac{1}{2}$ lb., which is lifted by a cam, $\frac{1}{2}$in., and dropped on the specimen. After each blow the specimen is rotated through 180 deg., and receives the next blow on the opposite side. The speed is limited by the cam, and is possibly about eighty to ninety blows per minute, so that a test which takes many thousand blows occupies a fairly long time to perform. The apparatus has not yet been in use long enough to say if it has any particular advantages or superiorities over other tests of a similar kind.

The party returned to town by a special train. In the evening a banquet, to which ladies were invited, was held in the Hotel Cecil.

The chair was taken by the President, Mr. John Gavey; and among those present were Mrs. Gavey, Lord and Lady Kelvin, Sir Alexander and Lady Binnie, Sir Charles and Lady Owen, Sir Wm. and Lady Crookes, Sir William and Lady Ramsay, Sir William and Lady White, Sir J. W. and Lady Swan, Sir A. B. and Lady Kennedy, Sir Henry and Lady Mance, Sir Charles and Lady Tupper, the Lord Mayor and Lady Mayoress of Manchester; Rear-Admiral Field, Dr. Glazebrook, Professor and Miss Pagliana, Mr. and Miss Spagnoletti, Dr. and Mrs. S. S. Wheeler, Professor J. L. Farny, Mr. P. J. B. E. Auzépy, Professor Dr. E. Budde, Dr. Emil Naglo, and Mr. Guido Semenza. The toast list was a long one, but the speeches were short. The healths of the King and Queen and of the rulers of the countries represented by the visitors at the banquet were drunk with enthusiasm.

In the absence of the Right Hon. Sydney Buxton, the toast of the visiting delegates was proposed by the President, both in French and English. He referred to the solidarity of learning, a solidarity to which engineers contributed even more than other learned societies. Wherever one engineer met another, they met not only as colleagues but as friends. The toast was responded to by Professor J. L. Farny, on behalf of the Association Suisse des Electriciens; Mr. P. J. B. E. Auzépy, the Consul General of France; Professor Dr. E. Budde, President Verband Deutscher Elektrotechniker; Dr. Emil Naglo, representing the President of the Elektrotechnischer Verein; Mr. S. S. Wheeler, President of the American Society of Electrical Engineers; and Mr. Guido Semenza, Honorary General Secretary of the Associazione Elettrotecnica Italiana. This gentleman, on behalf of the Italian electrical engineers, presented the Institution of Electrical Engineers with a bronze bust of Volta, and in a few well-chosen sentences, referred to Volta's relations with British engineering, and hoped that the gift might be a new link in the old chain of friendship between England and Italy. The President thanked the Italian engineers for their kindness in suitable terms, and at his request Professor Silvanus Thompson gave a brief description of Volta's associations with this country, and added an eloquent tribute to the great electrician's memory.

On Tuesday morning the members and their guests assembled at 9.30, and broke up into a number of groups. One of these set out to visit the London County Council Generating Station at Greenwich; another went to the Lots-road Generating Station at Chelsea; another to the Bow station of the Charing Cross Company; and others to the Post-office Telegraphs and Telephones Departments, and to the installation of the National Telephone Company. Our readers are already familiar with the general design of the various power stations visited, and there will be no need to refer to them in the present instance. A few words may, however, be usefully said regarding the gigantic undertaking of the Post-office, both in telegraphy and telephony.

In the telegraph department the visitors were shown practically everything, from the secondary batteries to the most delicate of transmitting and receiving instruments. Perhaps most interest was taken in the automatic machines, with which a speed of transmission of 400 words a minute is attained; but instruments in direct communication with far-off centres came in for a good share of attention. Naturally, from the point of view of actual study, it was a pity that only one hour could be spared for the inspection of such an amount of intricate detail.

From the Post-office the party was conveyed in its motor omnibuses to the building devoted to the Post-office telephones. Here in one building are two exchanges with connections to customers, approaching in numbers very nearly to 30,000. The visitors were shown the duct chamber through which the cables enter the building, and ascending from there they traversed one after another the various departments, and could see exactly how the whole system was worked. It happened that the time of the visit coincided with a period of great activity, and the operators were hard at work attending to the calls of the various customers. Among the points which were specially noticed were the registering meters by which the number of calls made by each customer are recorded, and the arrangements for testing faulty lines and investigating defects. The longest time out of a short hour was devoted to the trunk communication department, and the working was entered into and thoroughly understood by the visitors. For the benefit of our readers we may say that the trunk calls come to a board in charge of two attendants. These transmit the requests by telephone to a number of operators seated on each side of a long table. The details of the calls are entered on printed forms, which, when filled in, are deposited on a travelling band running in a channel down the centre of the table, and delivering on to a cross table at one end. Here they are sorted and delivered to messengers, who take them to various boards situated in different parts of the room, according to the locality with which it is desired to have trunk connection. Communication is then made between the original subscriber and the person with whom he wishes to speak. The printed slips are, after the call is over, sent to the accounts office so that records may be kept and charges made.

Leaving this place, after all too short a time, the party was conveyed to Greenwich, where it was joined by those which had visited the National Telephone Company's building and the Greenwich power station. After luncheon at the Ship Hotel, the Royal Naval College and other places were inspected, after which a return to town was made. The parties which had inspected the London stations were entertained at luncheon at the Austrian Exhibition.

In the evening was the annual conversazione, which was held, as is usual, at the Natural History Museum, where rather more of the exhibits were on view than has generally been the case – owing, no doubt, to the greater number of visitors—and an enjoyable evening was spent.

On Wednesday a most successful excursion was made to Windsor Castle, and afterwards up the river to beyond Boulter's Lock, a return to London being made at about 8.30.

Yesterday morning the visitors started very early in the morning from Euston on their long tour, which will include visits to Rugby, Birmingham, Manchester, Liverpool, Glasgow, Edinburgh, Newcastle, Leeds, &c. In our next impression we hope to give some account of this trip. To-day we only propose to discuss one of the numbers of things which the party will see. This is the applications of electricity to traction which have been made during recent years by the Lancashire and Yorkshire Railway.

In our issues of March 18th and 25th, and April 1st, 8th, and 15th, 1904, we gave a detailed description of the work which had been carried out up to that time in connection with the electrification of the Lancashire and Yorkshire Railway Company's line between Liverpool and Southport—see Fig. 1. It will be remembered that the contractors for the whole undertaking were Dick, Kerr and Co., Limited, of Abchurch-yard, Cannon-street, E.C.

Since the opening of the line in 1904 a number of developments have been carried out, and the line has been extended, and as it will be one of the features of greatest interest in the programme of the electrical engineers, we propose in the following article to bring our description fully up-to-date. In March, 1904, the electrified system embraced 47 miles of permanent way. At the present time the length is close upon 60 miles of single track, the extension being in part due to the linking up of Crossens. It will, perhaps, be of interest to refer briefly to the relative conditions obtaining under the new *régime* as compared with the time when steam locomotives were used for working the trains on this important branch of the Lancashire and Yorkshire Company's line. Then there were thirty-six trains per day in each direction between Liverpool and Southport, and a like number running in each direction between Liverpool and Crosby, a station some 6$\frac{1}{2}$ miles distant. The majority of these trains stopped at every station, and there were only a few expresses run in the morning and evening for the accommodation of business men. The express trains took 25 minutes to cover the distance—nearly 18 miles—between the two extreme termini. The stopping trains occupied 54 minutes. The stopping trains to Hall-road, which is just beyond Crosby, took 25 minutes, and the train mileage on the whole system was about 1900 per diem. With electric propulsion the railway authorities have been enabled to increase this to 3500 train miles per day, or very nearly double. The schedule time for the express trains between Liverpool and Southport remains the same—25 minutes—but there is one train per hour regularly instead of only a few trains in the morning and evening. The stopping time for the whole distance has, however, been reduced from 54 to 37 minutes, and that from Liverpool to Hall-road from 25 to 17 minutes. Moreover, the express trains are now run on to Crossens, beyond Southport, giving this place a service of seventeen trains each way during the day. The foregoing does not, however, represent all that will ultimately be achieved. Considerable extensions are in contemplation, and some of them are actually being proceeded with. The growth of traffic has compelled the railway company to equip for electric working all four roads between Bank Hall

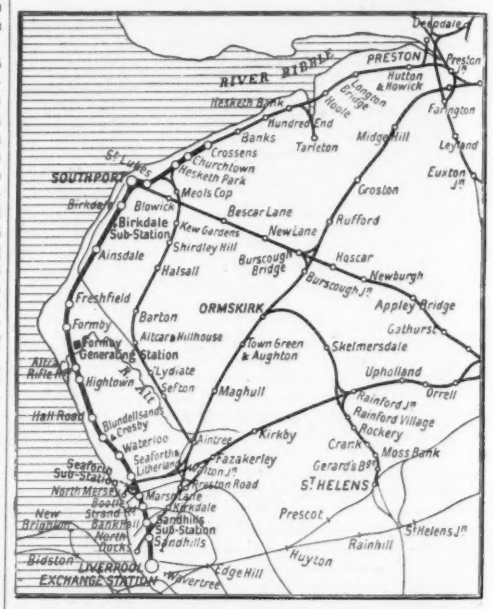


Fig. 1—RAILWAYS IN THE LIVERPOOL DISTRICT

and Seaforth Stations. Two roads are used for the fast, and two for local services. This work necessitated the equipment of eight miles of single track.

So much for the line originally electrified. The Lancashire and Yorkshire Company has by no means rested satisfied with this alone. It has launched out in other directions as well, and is electrifying other neighbouring lines of its system. We understand that matters have so far advanced that it is hoped before the end of the present year to have electric trains in operation between Liverpool and Aintree through Sandhills, Kirkdale, and Walton Junction, and that the North Mersey branch will also be completed, linking up not only to the Liverpool-Southport line at Seaforth, but also forming a through connection to the Liverpool Overhead Railway. The length of track which these extensions will add to the system amounts to some sixteen miles, which will bring up the total length of electrically operated track to about seventy-five miles. The work had progressed so far by the beginning of this month that a service of twenty-eight trains daily had been established between the Dingle station of the Liverpool Overhead Railway and a new station which has been built at Linacre-road on the North Mersey Branch. At the same time a service was also opened between the Exchange Station at Liverpool and the New Linacre-road.

The electrification of a railway renders easy the task of running trains of a capacity to suit the needs of the moment. This facility has been made the most of. The trains as run consist of two motor coaches coupled to one, two, or three trailers, according to need. The longer trains are worked during the "rush" hours in the morning and evening, and the lighter trains during the slacker hours of middle day and early afternoon. The empty weight of the motor cars is some 46 tons, and of

the trailers 26 tons, so that an empty three-car train weighs 118 tons, an empty four-car train 144 tons, and an empty five-car train 170 tons. Notwithstanding the heavy calls made on the line for the running of the increased service, opportunity is found for working a baggage car weighing 32 tons, which is kept more or less constantly in operation, and deals with baggage, goods, produce, fish, &c., which cannot conveniently be handled during the fifteen seconds station stops which is aimed at for the passenger trains.

The standard train consists of two first and of two third-class cars, the latter being at either end and equipped with two motor bogies, each carrying two 150 horse-power motors —Figs. 2 and 3. There are, therefore, eight motors, or 1200 horse-power per train. Both types of car are 60ft. long

Fig. 2—VIEW OF MOTOR BOGEY

and 10ft. wide—the widest in use in this country—and they have 8ft. wheel base bogies fixed 40ft. 6in. apart from centre to centre. We described the coaches at some length in the articles already referred to, and we need only say here that those of the first class hold 66 passengers, and of the third class 69 passengers each. A normal four-coach train will therefore accommodate 270 passengers. The motors, it may be added, are designed to develop their 150 brake horse-power at a speed of 470 revolutions per minute. Their weight complete is 6050 lb. each, 1920 lb. of this being for the armature, and 500 lb. for the gearing and housing.

The average four-coach train may occasionally require as heavy a current as 2500 ampères at starting. Such a current naturally requires special handling. The controller employed is composed of two power cylinders geared together and operated by one handle. One cylinder controls the four motors of the leading coach, the other the four motors of the rear coach. Either power cylinder might be entirely disabled or disconnected without interfering with the operation of the other cylinder. In fact, the whole may be considered as two separate controllers geared together—see Fig. 4. The train is electrically connected by means of three cables which traverse its whole length. Current is collected by shoes on the front and rear coaches, four shoes being simultaneously engaged. The two sides of the controller are in parallel. The connections of each side of the controller are identical, the current in each case passing through a main switch and circuit breaker to the controller notches. The two controllers being identical and being geared together, it follows that whatever happens on the portion governing the motors on the forward coach has its counterpart on the portion dealing with the motors of the rear coach. Alongside the main controller is a small reversing cylinder, the handle of which has three positions—"ahead," "reverse," and "off." The method of driving is as follows:—The reversing handle is placed in the "ahead" position, and on operating the power cylinder the whole of the eight motors of the train come under control. The reversing cylinder at the rear of the train has been left in the "off" position, and, in consequence, the two sides of the controllers are connected together and feed the rear motors. If it is necessary at any time to reverse the train, the forward reversing handle would be placed in the "reverse" position. This would have the effect of disconnecting the rear motors, and the backing of the train would be done entirely by the four motors of the front coach. On reaching the terminus the forward reversing handle is placed in the "off" position, which leaves matters so arranged that when the driving is done from the other end of the train proper contact has been established between the two sets of motors. (For further information regarding the controller, &c., we would refer our readers to our issue of April 1st and 8th, 1904.)

Connection has now been established between the Liverpool Overhead and the Lancashire and Yorkshire Railways, but since trains of about only half the weight of the Liverpool and Southport trains can be employed on the overhead road, a system of multiple unit contact has been designed by Dick, Kerr, and Co., with a view to dividing any ordinary train, so that one of the permitted weight might be obtained. This system, which is giving very satisfactory results, the electrical engineers will have an opportunity of studying to-morrow.

The five-car trains are allowed about three minutes longer for the stopping trips between Liverpool and Southport than the four-car trains which do the journey in 37 minutes. The watt hours per ton-mile for these runs average about 80. The expresses between Liverpool and Birkdale only absorb about 53 watts per ton-mile. The current consumption per ton-mile over the whole system is 82·3 watt hours, but in considering this figure the frequency of the Hull road service and the station density between this point and Liverpool must be taken into account. It may here be mentioned that on this part of the line the stations average less than a mile apart, but that they are more widely separated on the northern portion.

Although we carefully described the method of power distribution when we described the line at the time it was opened for service, we may, perhaps, usefully recapitulate a few of the leading features. The electricity is generated at the Formby Power Station, which immediately adjoins the line at a distance of some 10¼ miles from Liverpool. The initial pressure of the current, which is three-phase, is 7500 volts, and at this it is transmitted to three sub-stations, a fourth being actually in the same building as the generating plant. The distances of the sub-stations from Liverpool are as follows:—

	Miles.
Bank Hall, distant from Liverpool	2
Seaforth, ,, ,, ,, ...	3⅜
Formby, ,, ,, ,, ...	10¼
Birkdale, ,, ,, ,, ...	16½

In these sub-stations the 7500-volt current is first of

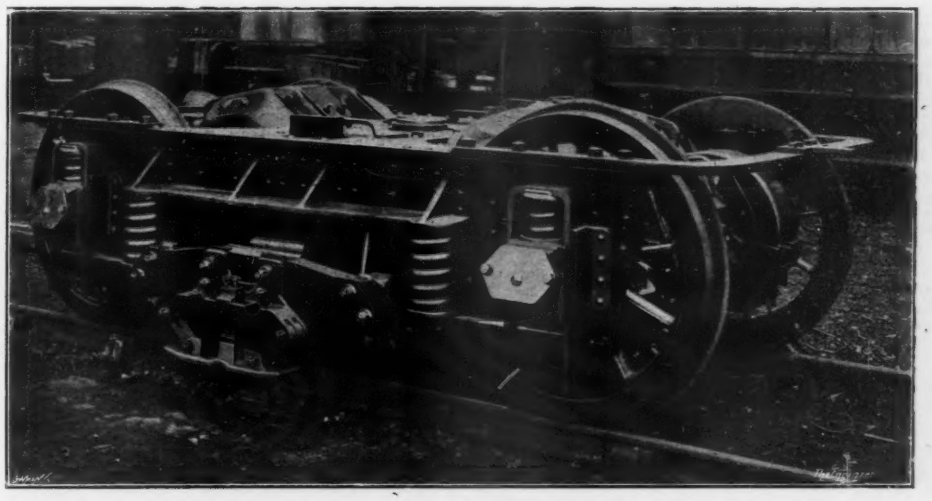


Fig. 3—EIGHT-WHEEL MOTOR BOGEY

all stepped down in static transformers, and is then converted in rotary converters to direct current at 650 volts pressure. Allowing for loss in transmission, &c., the maximum voltage supplied to the trains is about 600. The sub-stations are all near the line, and, except for short connecting lengths, low-tension cable is practically dispensed with.

In the first instance the scheme was designed for working twelve trains. Almost from the first, however, it was found necessary to employ fifteen trains. Then later on a ten-minute service was started between the Liverpool Overhead and the Liverpool Southport lines, and later still, a system of through trains between Southport and the Dingle additions. All of these taken together involved heavier demands for current being made on the power-house than were initially contemplated. One way of meeting the difficulty would have been to have installed further generating plant. This, however, the railway company, acting on the advice of its contractors, decided not to do, but instead to lay down a system of storage batteries connected to the line at different points. It was intended that these should be capable of dealing with the severe peak loads inseparable from the electric working of a railway requiring a fast and frequent service, short runs between many stations, and a high acceleration.

The batteries selected were of the Tudor Company's make. They have been installed in four battery sub-stations placed in positions on the line where the least influence of the rotary sub-stations was felt. The first was erected in the Great Howard-street goods yard, about a quarter of a mile distant from the Exchange Station, Liverpool. This battery has a capacity of 1300 ampères discharge for one hour, or a maximum output for short periods of 3300 ampères. Another battery sub-station was placed at Hall-road, at a point roughly midway between the Seaforth and Formby rotary sub-stations. It is at this point, it will be remembered, where the heavy local Liverpool traffic turns back. This battery has an hourly discharge capacity of 1600 ampères, and a maximum output for short periods of 4000 ampères. The third battery sub-station is at Freshfield, and the fourth at St. Luke's, which is the first stop beyond Southport on the way to Crossens. The Freshfield battery has a capacity of 1000 ampères for one hour, and a maximum discharge of 2500 ampères.

By placing the batteries in these positions relatively to the rotary sub-stations, we understand that an equilibrium in voltage and load is kept up, while steadiness of output from the power-house, reduction of peak loads, and general economy of generation is secured. Each battery is controlled by an automatic reversible booster, the plant consisting of a shunt-wound motor directly connected to a booster capable of giving the necessary rise in voltage.

The Great Howard-street sub-station is made use of for other purposes in addition to providing current for working the trains. Besides the batteries motor generators are installed, and the company now conducts all the operations of the goods yard by means of electric power derived from this sub-station, as well as carrying out all the terminus and yard lighting. In addition to this, the whole of the energy required for light and power in the company's Exchange Hotel is obtained from the same source. Hitherto this has been derived from an out-of-date engine house, which, in addition to working the heavy lifts in the hotel, drove a great number of capstans in the goods yard. A considerable economy is looked for from the change.

The equipment of the Walton Junction and North Mersey Branch necessitated the erection of another sub-station. This has been placed at Aintree, and will contain two rotary converters each of 600 kilowatts capacity, with the necessary static transformers, &c. Each unit will be a duplicate of that originally installed in the earlier sub-stations. This sub-station will, in addition, be equipped with a storage battery of Tudor cells, having a capacity for giving out 1500 ampères for one hour. This battery will be connected to the third rail through a reversible booster in a manner similar to that which has been employed at the other battery stations.

The Aintree sub-station will be connected by high-tension conductors with the Seaforth sub-station. These conductors, it may be mentioned, are run overhead in two sets of three lines, the conductors having a cross section of 0·1 square inch, and having a length of two miles. In Fig. 6 is given a diagram showing the arrangement of the high-tension conductors, with the lengths and cross sectional areas of these. The high-tension cables are in each case laid in triplicate. As a matter of fact, all three cables are used in actual running, but if one were to break down, the two remaining could do the work without the drop or the current density exceeding the permissible limit. They are of the triple triangular type, diatrine paper insulated, lead covered and armoured, and they are laid on the solid system.

A few words may, perhaps, be said regarding the fine

power station at Formby, which was not in full working order at the time our original description was published. A very fair idea of the arrangement of the engine-house may be obtained from the engraving which we give on page 654 though, perhaps, its size cannot be fully appreciated. It is, as a fact, 65ft. wide and 280ft. long, while the boiler-house which runs beside it, and is of the same length, is 56ft. wide. The four horizontal combined sets shown in the background are of 1500 kilowatts each. The engines made by Messrs. Yates and Thom as sub-contractors are cross-compound, with cylinders 32in. and 64in. by 4ft. 6in. stroke, and designed to indicate 2310 horse-power at seventy-five revolutions per minute with steam at 160 lb. pressure and superheated by about 80 deg. The engines will, however, give some 20 per cent. more power than this if called upon. Each engine has its own condensing apparatus. The vertical engine in the right foreground has cylinders 28in. and 46in., and a stroke of 3ft. 6in. It is designed to give 1180 horse-power at ninety-four revolutions per minute. It also has its own separate condenser. The alternators are of the ordinary three-phase

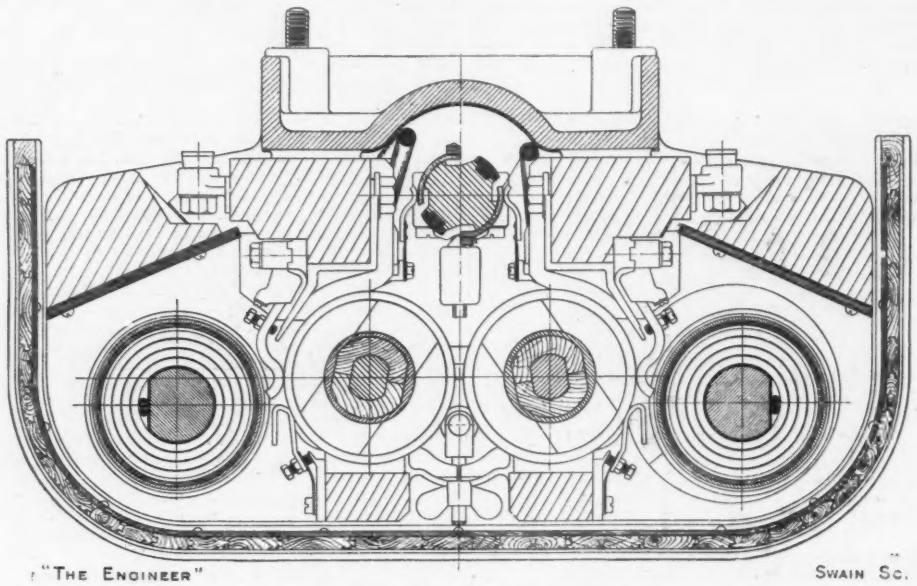


Fig. 4—SECTION OF CONTROLLER

develop 600 kilowatts direct current at a pressure of from 600 to 650 volts and a speed of 375 revolutions per minute. The static transformers are cooled by air blast, and each have a capacity of 200 kilowatts. They are circular, and are built up of copper strip wound on edge. The secondaries are inside next the core, and the primaries above and outside. The blowers which provide the air blast are composed of a Davidson Sirocco fan driven by a 5 horse-power Dick-Kerr motor. There are two blowers in each sub-station, and the capacity of each fan is 8000 cubic feet of air per minute at a pressure of from 2in. to 3in. of water.

The permanent way was described in our issue of March 25th, 1904. It is peculiar in having two extra rails—one insulated and the other uninsulated—in addition to the running rails. One of these extra rails is placed outside the running rails, and is carried on insulators. The other extra rail is generally laid midway between the running rails, and is spiked uninsulated to the sleepers—see Fig. 5. This latter rail forms the principal return, but is cross-bonded to the running rails. The two

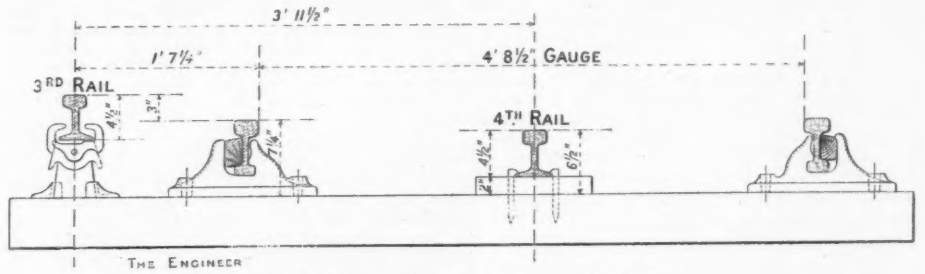


Fig. 5—CROSS SECTION OF PERMANENT WAY

Dick, Kerr type with which our readers are familiar. They work at a periodicity of twenty-five cycles and generate current at a pressure of 7500 volts. For the larger engines the output is 1500 kilowatts, and for the smaller 750 kilowatts. There are sixteen Lancashire boilers 32ft. by 8ft. 6in., made by Yates and Thom. For further particulars of the station we would refer our readers to the above-mentioned articles.

The various rotary sub-stations on the Liverpool and Southport line are identical in equipment, and vary only in the capacity of the latter. Three of them—those at Seaforth, Sandhills, and Birkdale—have each four rotary converters, while there are only three at Formby. In all cases, however, there is provision for extension. Each converter has its corresponding groups of static transformers and high-tension oil switches, the latter being placed underground below the floor level of the sub-station. A typical interior is shown on page 654. The rotary converters have eight poles, and are designed to extra rails are bonded in the usual way, but the running rails are not so bonded, their ends, instead, being connected to the return rail. Slippers, of course, press on both the extra rails. We are informed that this arrangement has given great satisfaction, special advantages being reaped by the abolition of the troublesome bonding of the running rails. The two extra rails are of equal cross section, and consist of mild steel of a specially high conductivity, the electrical resistance being not greater than seven times that of an equal cross section of pure copper. One of the objections to a third rail laid near the ground level is the danger of fatal accidents from shock. In this particular instance gaps have been left at all level crossings, the ends being bonded by underground cables. Moreover, timber guarding has been provided at all busy places. At most stations the third rail is interrupted and the ends connected by cables to section switches. By means of these switches any portion of the line may be cut out at will. There have been fatalities on the line,

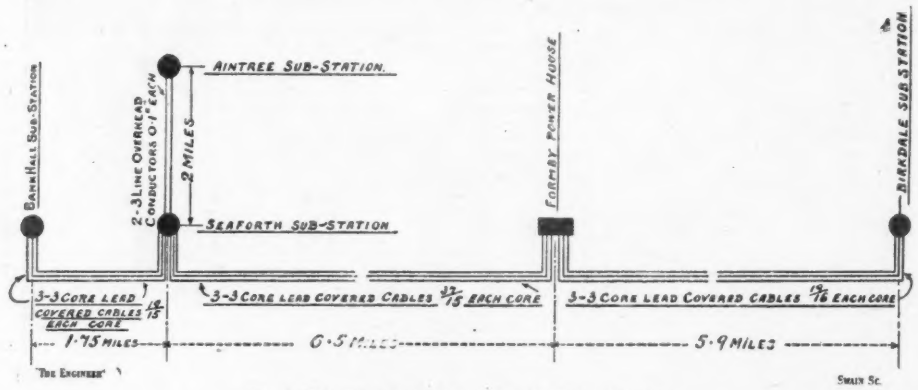


Fig. 6—DIAGRAM SHOWING HIGH TENSION CABLES

but it is claimed that in each of the few cases which arose in the early days of the electrification causes were present which in no way reflected on the railway company or its contractors. For more than a year now close upon 50 miles of permanent way have been effectively operated by electricity and maintained without hitch or halt and without anything in the nature of a serious electrical shock or accident.

It is interesting, as far as upkeep is concerned, to find that the cost of renewals of insulators, bonds, and other details which go towards the completion of a third rail are almost negligible where the insulators have been well set and the rail itself properly anchored. Out of 30,000 insulators, the renewals, it is said, do not amount to more than 300 insulators per annum. The ordinary cost of maintenance of the permanent way is, of course, increased, but not, we understand, to any serious extent. If it be assumed that the straightforward re-laying of an ordinary road can be done at a labour cost of 7d. per yard, then the extra cost involved by the presence of a third rail will, we are informed, not exceed 1d. if bonding be eliminated, as the only complication introduced is an alteration in the lifting of the running rail next to the live rail and the attaching of an insulator to every fourth new sleeper. Generally speaking, the bonding of the live rail will not be disturbed, and the bonding of the running rail to the return rail is a matter of little cost, involving only the drilling or punching of a hole in the end of each new running rail and the pressing therein of a bond head. As regards leakage, the total loss over 50 miles has, we are informed, not at its worst exceeded an amount which is hardly measurable. On wet and slushy days, and after prolonged rain or snow, the loss is reported to be less than 2 ampères per mile.

OBITUARY.

CAPTAIN J. D. CLINK.

By the recently reported death of Captain J. D. Clink, of Greenock, at the advanced age of eighty-four, an old-time mariner and shipmaster and a noted Clyde shipowner has passed away. His death took place, after a lengthened illness, at his Greenock home on the 18th inst. A native of Greenock, he went to sea when he was only thirteen years of age, and after a service of ten or twelve years in subordinate capacities he was appointed captain of a sailing vessel in 1851. He sailed in all parts of the world, and had some interesting experiences in connection with the carrying of stores to Black Sea ports for the British troops during the Crimean War. He retired from the sea in 1861, since when he has been engaged as a shipowner, owning various sailing vessels. He took a prominent part in Greenock public affairs, and was for a number of years a member of the Corporation, acting as a magistrate for three years. He was the oldest member of Greenock Harbour Trust, and for many years sat on the Clyde Pilot Board and the Clyde Lighthouses Trust. He was also a member of the Scottish Sailing Shipowners' Association, and acted as president for some time.

J. P. LACY.

THE death is announced of Mr. J. P. Lacy, of Birmingham, who was for some years chairman of the Galvanised Sheet Makers' Association, and one of the best known men on Birmingham Exchange. Mr. Lacy's death took place on Wednesday, the cause being heart failure following an illness. He was a director of Kynochs, Limited, of Birmingham, and of the Metropolitan Amalgamated Railway Carriage and Wagon Company. Prior to the amalgamation of the Patent Shaft and Axletree Company, Wednesbury, with the Metropolitan Company, Mr. Lacy had for many years held the chairmanship of that concern.

ARTHUR COOTE.

A RAILWAY accident occurred on Friday midnight, about six miles from Glasgow, on the Caledonian Railway, resulting in the death of Mr. Arthur Coote, of Kensington Gardens, W. Mr. Coote was travelling in the express train from Aberdeen to Glasgow in order to be present at the launch of H.M.S. Agamemnon. Another train, made up of a covered truck van, three fish vans, a fish truck, and a composite passenger carriage, carrying about twenty passengers, was going in the opposite direction. Through some unexplained cause one of the fish vans became derailed, hit a bridge, rebounding against the first-class compartment in which Mr. Coote was the only passenger. Mr. Coote was a director of Hawthorn Leslie and Co., Limited, of Newcastle-on-Tyne and London, and chairman of the Anglo-Australasian Steam Navigation Company, Limited.

INSTITUTE OF SANITARY ENGINEERS.—The summer meeting of the Institute of Sanitary Engineers will be held in Manchester.

THE FOREST SERVICE of the United States Department of Agriculture has ascertained from returns representing 95 per cent. of the steam railroad mileage of the United States that 80,051,000 wood cross ties were purchased by these roads in 1905. On this basis the total number of ties used by the steam roads in 1905 was 84,400,000, representing nearly 3,000,000,000ft. of lumber, board measure. Reports came from 750 steam railroad companies, having an aggregate length of line of 278,262 miles. Oak ties were 47·5 per cent. of the total, pine 21·9 per cent., cedar 8·7 per cent., chestnut 5·8 per cent. The remaining 16 per cent. was largely fir, cypress, and tamarack. Preservative treatment was given to 7,615,000 ties, representing nearly 10 per cent. of the number reported.

ASSOCIATION OF MUNICIPAL ENGINEERS: SCOTTISH DISTRICT.—The annual meeting of this body took place at Berwick on the 15th inst. The members were formally received in the Town Hall by the Mayor, the Sheriff, and Councillors, and afterwards met in the Museum, where Mr. Holmes, burgh surveyor, Govan, presided, in the absence of Mr. Collins, Norwich, the president. Two papers were submitted for discussion, one by Mr. R. Dickinson, borough surveyor, Berwick, on the "Municipal Works of the Borough;" and another by Mr. A. H. Goudie, burgh surveyor, Stirling, on the "Plan and Register of Streets as Provided for in the Burgh Police (Scotland) Act, 1903." Thereafter the visitors were entertained to luncheon by the Mayor, after which they drove a circular tour, crossing the Whitadder and Union Bridges on the way. On the return they made an examination of Berwick waterworks. In the evening the annual dinner was held.

RAILWAY MATTERS.

ON 20th inst., Sir Hamilton Goold-Adams, Lieutenant-Governor of Orange River Colony, opened the railway line between Bethlehem and Kroonstad.

ACCORDING to the *Mexican Herald*, the contract for the construction of the first 80 kiloms. of the line between Irapuato and Paruandiro has been awarded.

AFTER a hearing extending over many weeks the London Outer Circle Railway Bill was rejected by Sir George Doughty's Committee of the House of Commons last week.

THE *Journal de St. Petersbourg* of 20th May 2nd June states that plans for the construction of a railway between Stretensk and Nicolaievsk, with branches to Blagovestchensk and Khabarovsk, are at present under the consideration of the Minister of Ways of Communication.

MANY experiments are being made with electric and gasolene motors for suburban trains, but no real step in this direction has been taken in Chicago, although it is hoped that it will be soon, in order to alleviate the present intolerable nuisance of smoke from the many locomotives.

ARRANGEMENTS have been completed by the Midland Railway Company for the sale to the Italian State Railways of fifty locomotives of a class of which they possess rather more than are required for a particular kind of traffic, but which are calculated to meet the necessities of the Italian railways.

MILWAUKEE, a distance of 100 miles north, will soon be connected with Chicago by electric railway. This road will have four lines, two for expresses and two for slow trains, and will connect towns with a combined population of over 2,500,000, as well as open up the land along the shores of the lake for suburban residences.

IN order to reduce the danger of collision on single-line railways on the Bavarian State Railways, the Bavarian Minister of Public Works has decided to employ wireless telegraphy for sending instructions and warnings from stations to approaching trains. The experiments which have been made have so far proved highly successful.

THE railway system of Bulgaria is being steadily developed, and, besides the grant made by the Sobranie for the extension of the Radomir line to the Macedonian frontier, and the connecting of the lines to the north and south of the Balkans, a further grant of £1,000,000 has been made for the construction of several small lines.

THE scheme of the Peruvian Government to construct a railway over the Andes to unite the coast provinces of the Pacific with their immensely valuable undeveloped land in the interior and extending through to the Atlantic provinces, is still in abeyance. Negotiations are in progress for raising a loan for railway construction, but so far the route of the proposed railway has not been decided upon.

THE Eastern Bengal Railway has lately completed a survey of a line on the 2ft. 6in. gauge from Krishnagar, on the Ranaghat-Moorshedabad Railway, to Jellinghee, 56 miles. The line is estimated to cost about Rs. 14,00,000, but it has not yet been decided whether the financing and construction will be undertaken by private enterprise, under a guarantee from the District Board of Nuddea, or by the District Board itself.

THE capacity of Russian goods wagons has been increased 20 per cent. without the intervention of any new construction, but simply by the order of the Ministry of Transportation that the standard freight car, heretofore limited to a load of 750 poods, hereafter may carry 900 poods. It is not many years ago that the permissible wagon load in Russia was increased from 600 to 750 poods; but then some strengthening of the springs was required.

THE new Pennsylvania Railroad Station in New York, for which the plans are now practically perfected, will be exceptional among all the railroad stations of the world in the number and convenience of its entrances and exits, says the *Railroad Gazette*. This condition is due to the fact that each of the four sides of the structure is a front, opening respectively on two wide avenues and two important streets, which latter have been widened by the company to 80ft. each.

THE Government of Guatemala has lately been interesting itself to secure a means of communication by rail along the coast of the departments of Quezaltenango and San Marcos. The idea is to extend the existing railways intersecting rich zones producing coffee, sugar cane, rubber, cocoa, and corn by a line running from Caballo Blanco to Coatepeque, and to continue from Coatepeque to Ayutla on the Mexican frontier, thus forming another link in the Pan-American Railway system.

THE London Brighton and South Coast Railway, in conjunction with the Great Western Railway, has arranged for a through train—first, second, and third-class—to run on week days on and from 2nd July next, leaving Brighton at 11.30 a.m., and reaching Paddington at 1.10 p.m., returning from Paddington at 3.40 p.m., and arriving at Brighton at 5.17 p.m. These trains give connections from the principal places on the South Coast with the principal places on the Great Western Railway.

ONE hundred and two spans, aggregating a length of about 10,800ft., or more than two miles, are required for the new railway bridge across the Hoang Ho. It will serve as a crossing for trains of the Hankau and Peking Railway, and will assist in shortening the time between those cities—754 miles apart—to thirty-six hours. The river has here a width of about two miles, but is shallow. The bridge is constructed of steel, but not of the heavy sections common in American and European practice.

ADVERTING to the notice published on page 589 of the *Board of Trade Journal* of 29th March last, and to that on page 206 of the issue for 1st February, respecting the development by the Government of the Italian railways, the report on the finances of Italy by Mr. C. des Graz, Counsellor of H.M. Embassy at Rome, states that it is the intention of the present Government to lay before Parliament a complete financial scheme providing for the large expenditure requisite on the State Railways for a period of ten years. It is estimated that £54,000,000 will be required.

THE Mexican "Diario Oficial" of 29th May contains the text of a contract entered into between the Mexican Government and Senor Lic. D. Pablo Martinez del Rio, the representative of various Mexican Railway Companies, for the construction of a railway terminus at Vera Cruz. The contract also provides for the provision of wharves, overhead cables, cranes, &c., to facilitate trade at the port. Free importation is allowed for the term of five years of all materials required for these works; during each of the ten years following, goods to the value of 20,000 dols. may be imported free of duty.

THE Southern Pacific Railway is building a line in Mexico to Guadalajara which represents a very cosmopolitan co operation in labour and materials. It is an American railway, built on Mexican territory, with rails from Spain, carried to the United States on German steamers, and unloaded by Jamaica negroes. The sleepers are from lands in the Orient acquired by the Japanese in their war with Russia. The earthwork and laying of rails and sleepers were done by Mexican Indians, Chinese, and Greeks, under the supervision of Irish gangers, American engineers, and Mexican Government inspectors.

NOTES AND MEMORANDA.

CAOUTCHOUC oil, it is said, has proved to be very efficient for preventing rust, and has been adopted by the German army. It is applied by spreading over the surface of the metal with a piece of flannel in a very thin layer, and is allowed to dry.

VALVES on iron pipes of hydraulic systems are often channelled out by iron scale carried along by the water. This scale is almost as bad and abrasive as sand. An increase of lead in the mixture will make a metal which will resist the wear better.

TESTS are being carried on at Indian Head for a new arrangement of the turrets contemplated for the new battleships to minimise the shock of the firing of the guns of the upper turret over the lower. It is planned to so arrange a steel plate between the turrets, with air space below and above so as to carry up and away the shock.

EXHAUSTIVE work upon the specific heat of superheated steam is being carried out at Sibley College, Cornell University, and at Charlottenburg, Germany. It will be interesting to see how nearly the results of these two entirely different lines of investigation conducted by the most eminent authorities in the world upon heat physics agree.

ACCORDING to the *Manufacturers' Record*, of Baltimore, there are 642 cotton mill companies and firms in the South of the United States, with 9,440,647 spindles and 216,293 looms. The actual number of mills is larger than 642, as some of the firms have more than one mill. South Carolina continues to hold the position of the foremost cotton manufacturing State of the South, having 136 mills, with 3,329,408 spindles and 84,244 looms. North Carolina is second with 243 mills, 2,463,982 spindles, and 51,265 looms. Georgia is third with 113 mills, 1,770,967 spindles, and 33,590 looms. Large additions continue to be made.

IN a paper on "The Rusting of Iron," read by Mr. J. T. Nance before the Chemical Society, it was pointed out that the interaction between metallic iron and ammonium chloride solution takes place with the evolution of hydrogen and the liberation of ammonia, the metal passing into solution in the ferrous state. The rate of rusting of iron in these solutions varies in such a manner as to suggest that the attack on the metal is due to the catalytic action of the hydrogen ions formed by the hydrolysis of the ammonium chloride. This view is supported by the fact that chlorides of weak bases accelerate rusting far more than those of stronger bases, and the effect of acids is also approximately proportional to their avidies.

COPPER may be deposited upon aluminium by the use of an anode of pure copper and an electrolyte of water, with a few drops of sulphuric acid. After the current has been in action for some time copper sulphate is formed, and from this the copper is deposited. After thirty minutes the plate was taken out in a recent experiment and well washed in water, then in a solution of hydrochloric acid, then in sodium hydroxide, and again in water. This operation was repeated several times, the final result being an even deposition of copper all over the plate. Further experiments included the deposit of antimony upon the coppered aluminum plate. On the coppered aluminium cathode the antimony adheres firmly, the current density being 0·0013 ampères per square inch, with a pressure of from 1 to 1·5 volts.

A CONSIDERABLE advance took place in the output of lignite in Germany during 1905. In 1904 the production of lignite amounted to 48,500,222 tons, whereas in 1905 it increased to 52,473,526 tons, or by nearly 4,000,000 tons; and in the first four months of the present year the lignite mines yielded 18,285,000 tons, being an augmentation of 1,356,000 tons for the term of the current year. According to the *Iron and Coal Trades Review* the impetus imparted to the lignite industry in the past eighteen months is due to two causes. In the first place, the miners' strike early in 1905 gave this particular branch an upward movement; and secondly, scientific progress has opened up new branches of application for lignite briquettes, which now offer considerable competition to pit coal or pit coal briquettes.

THE new United States battleship Georgia, on her official trial off the Maine coast on June 14th, proved herself the fastest vessel of her class in the navy, and she made a record of 19·26 knots an hour, exceeding by more than a quarter of a knot the speed required by contract. The first hour's run was the best, 19·33 knots being made. On the second hour 19·27 knots were made, 19·241 in the third, and 19·20 in the final hour. During the last hour the supply of picked coal gave out, and ordinary fuel was used. This reduced the speed for that hour and brought the average down correspondingly. On the builders' trial, held June 13th, off Rockland, the indications were that 118·9 revolutions of the propeller a minute would develop the contract speed required. The average attained June 14th was 122·28 revolutions a minute.

THE Teltow Canal system is twenty-five miles long, and is of sufficient width to allow two 600-ton vessels to pass each other. The vessels are hauled by means of electric locomotives fed from overhead wires and running on the towing path. The electric current is generated in a power station close to the canal by two 1000 h.p. Zoelly steam turbines, each working a large three-phase generator and a small continuous-current generator. The three-phase generators supply the mains along the whole length of the canal with a current of 6000 volts at 50 periods per second; the continuous-current generators supply current for working the tractors in the immediate neighbourhood of the power station. For working the further reaches of the canal a sub-station is provided, in which the high-pressure three-phase current is converted by rotary transformers into continuous current for working the tractors.

IT is said that the United States Navy Department has been unable to reach any definite conclusions from the reports which have been made on the new propellers of the cruiser Charleston, which has been sent to Rockland twice for tests. It has been found very little difference exists between the new and old screws on the Charleston, except that at high speeds the new propellers give better results, and at lower rates the old propellers do best. It is further stated that the results of the trials of the St. Louis tend to show that it makes but little difference which propellers are used on that class of vessels. The reason assigned for the vessels not making the speed which could be expected of them is that the original designs and contracts provided for a mean draught of 23ft. 6in. for vessels of this type, and a change was made to 22ft. 6in., while the other dimensions of the vessels remained the same.

IN a paper read recently before an American scientific institution by Prof. R. T. Stewart, on the collapsing pressure of steel tubes, the results of tests are said to show: first, that length was of practically no influence on the strength provided the tube is longer than about six diameters; secondly, that every known formula for the collapsing strength of tubes is radically incorrect. From the results of both series, the author deduced the following formulæ, of which the first is for values of P less than 581 lb. per square inch—or $t \div d$ less than 0·023—and the second is for values greater than these:—

$$P = 1000 \left(1 - \sqrt{1 - 1600\frac{t^2}{d^2}}\right)$$

$$P = 86{,}670\frac{t}{d} - 1386$$

where P = collapsing pressure, in pounds per square inch; d = outside diameter of tube in inches; t = thickness of wall of tube in inches.

MISCELLANEA.

IT is proposed to fix the minimum wage of all permanent workmen in the service of the Paddington Borough Council at 30s. per week.

ON June 2nd the U.S. Senate passed a resolution providing for the purchase of supplies for the Panama Canal in the United States, unless the President deems the prices unreasonable or extortionate.

THE foundations of the new County Buildings, Chicago, will consist of 126 cylindrical concrete piers, resting upon bed rock at an average depth of 115ft. below the street level and varying from 4ft. to 12ft. in diameter.

THE Board of Trade are in receipt, through the Foreign-office, of information to the effect that the Norwegian Customs Department have recently issued instructions to Customs officers to admit reaping machines into Norway free of duty until further notice.

THE rolling mills of Chicago are estimated to have turned out in 1905 a product valued at £17,000,000, double the amount produced in 1904, while the wholesale trade in manufactured iron increased 35 per cent. to £8,700,000, and pig iron 100 per cent. to £9,600,000.

THE increasing irrigation in the Western States of America continues, and producing farms are springing up where four years ago only cactus could grow. The United States Government has in these four years built 77 miles of main canal, 54 miles of branches, and 18 miles of ditches. A large amount is still to be spent, to be repaid in instalments by the settlers taking up the land.

A SOMEWHAT novel industry has been started at Hinckley, Minneapolis, for extracting from Norway pine stumps by a retort process which has been patented, turpentine, oil of tar, tar, acid, and charcoal, and it is said to be working satisfactorily. It is still in an experimental stage, but should it succeed it would be of much importance to this district, as the supply of pine stumps is practically unlimited.

THE Stettin municipality has sanctioned an extension of the harbour, which will comprise four docks with a width of 108 yards each, the adjacent ground being reserved for industrial undertakings. This extension has been decided upon with a view to furthering and facilitating local industries, and to encourage the establishment of new works. These docks will be built on the Parnitz, a branch of the river Oder.

THE U.S. Congress has artfully avoided the issue on the question as to whether John Paul Jones or John Barry was the real father of the American Navy, by authorising the erection of a £10,000 monument in honour of each of those sea warriors. This arrangement will probably, says the *Army and Navy Journal*, not reconcile the contentions of the partisans of the two commanders, but it will be recognised as a highly judicious compromise on an exceeding difficult question.

THE British Consul at Bordeaux reports the probability of diminished shipments of United States agricultural machinery this year to his district in view of the large stocks left on hand in 1905. He remarks that the higher price of British farming machinery is slowly but surely reducing each season the British percentage of the total of farming machinery coming to France. There are exceptions, however, in the case of certain classes of machines, particularly in that of British portable steam engines, which hold their own and are even increasing in favour.

THE British Consul at Bordeaux reports that an interesting novelty was placed upon the Bordeaux market at the beginning of 1906 in the shape of a small low-speed "essence" engine for farm purposes, such as pumping, straw-cutting, or any other farm or domestic requirements for a handy motor; these engines, running at 300 revolutions per minute instead of the 1500 to 2000 revolutions of the ordinary French engine, are particularly adapted to use by the peasantry. The two horse-power engine of this class can be sold retail in Bordeaux for £32.

A WASHINGTON telegram says that the tender of the firm of William Cramp and Co. for the construction of one of the 16,000-ton battleships Michigan and South Carolina, which are to be completed in forty-two months, is the lowest which has been received. Messrs. Cramp's tender is £708,000. As one firm will only be allowed to contract for one battleship, Messrs. Cramp's offer will be accepted, unless the Navy Department decide to accept the plans of builders including turbines, instead of adhering to the department's original plan. The lowest bid including turbines is £737,800. The next lowest tender to Messrs. Cramp's is £717,000.

THE Boston, Cape Cod, and New York Canal Company, which proposes to make the long-talked of Cape Cod Canal, has submitted plans to the Massachusetts Land and Harbour Commissioners, showing the scope of the proposed waterway, which will greatly shorten the water route between New York and Boston and points to the north, as well as eliminating perils of navigation, says the *Iron Age*. The northern approach is at Barnstaple Bay, Sandwich, and from there the route is through Sagamore, Bournedale, Bourne, and the Monument River to its mouth at Buzzards Bay. The plans are for a canal 100ft. wide at its bottom throughout, and 250ft. wide at its entrances. The minimum depth will be 25ft. below mean water level.

IN 1722 Reamur published the fundamental principles for the malleable cast iron process; but it is of comparatively recent years that the industrial world has utilised this knowledge. It was found that if a casting too hard to work were exposed to a continuous high heat for a number of days, imbedding in rolling mill scale—hammer slag—or iron ore, the casting would entirely change its nature, and at the time stated Reamur had collected those observations and found the principles which governed this change in the cast iron. The present generally accepted theory of the malleable cast iron process is to decarburise the metal by some oxide, which will impart a portion of its oxygen to the carbon in the metal at a red heat, forming carbonic oxide, which is given off, thus extracting the carbon. The oxidising re-agents usually employed are rolling mill scale and red hematite iron ore.

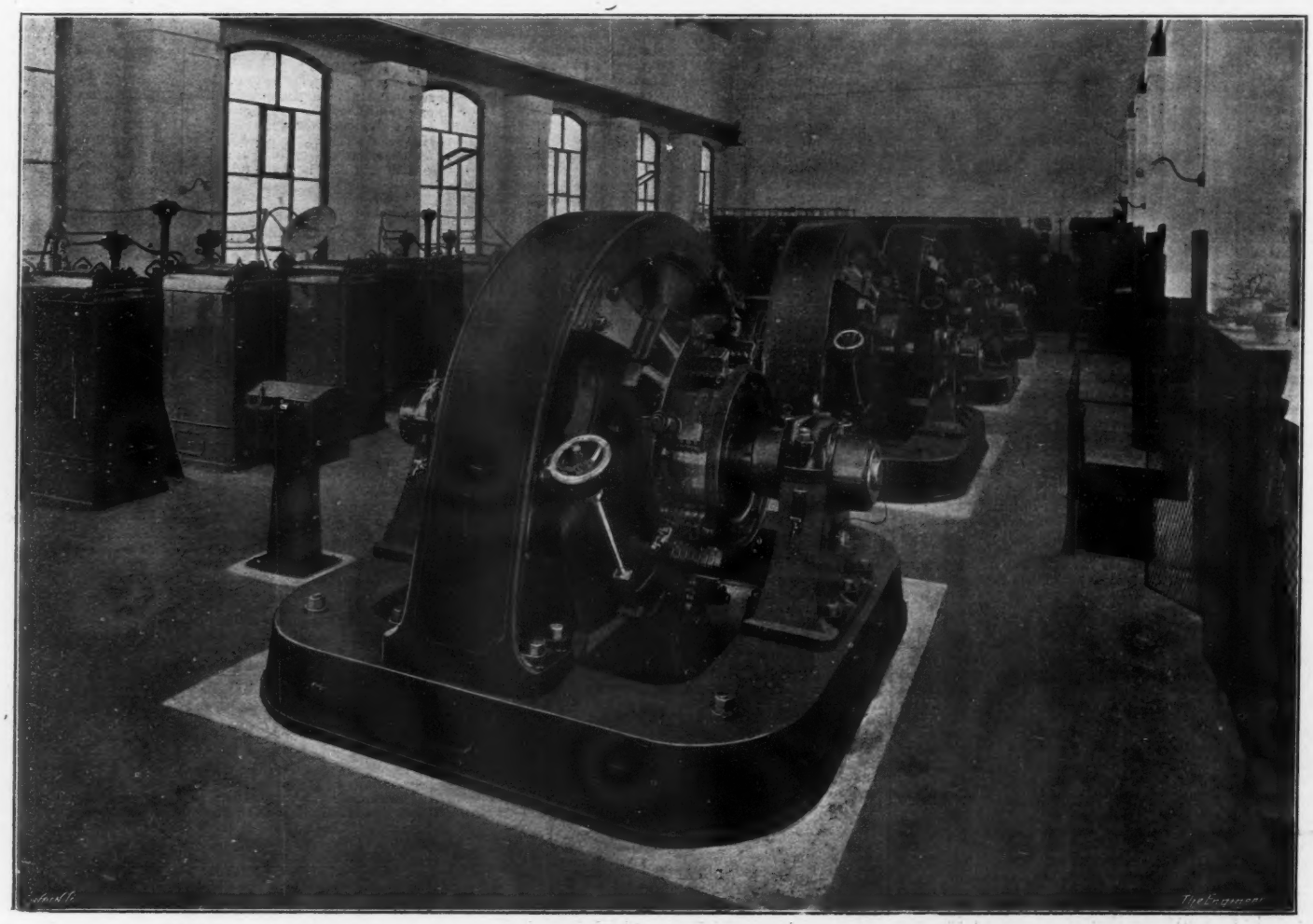
THE possible introduction of motor cars into Bulgaria has lately furnished a considerable correspondence between British motor car makers and his Majesty's Consulate-General, but up to the present there has been no real opening for British firms in this branch of trade. The total number of motor vehicles in the country does not probably exceed a dozen, of which number about half, of French make, are in use in the capital for collecting letters and parcels and conveying them to the railway station. The experiment has proved successful, and the Bulgarian Postmaster-General hopes next year to see the post-offices of all the principal towns in Bulgaria provided with a similar service. The director of the Bulgarian Railways, another enthusiastic advocate of automobiles, hopes next year to obtain a small credit from the Sobranie which will enable him to start a motor service connecting the towns in the interior of the Principality with railway stations for the conveyance not only of passengers and merchandise, but also the Government mails. There are also rumours that, thanks to private enterprise, next year will see the establishment of a service of motor omnibuses between Sofia and Banki, a village about ten miles distant from the capital, and famous for its thermal springs, and also between Sofia and Cham Koriya, a fashionable resort during the summer months.

ELECTRIC TRACTION ON THE LIVERPOOL AND SOUTHPORT RAILWAY

DICK, KERR, AND CO., LIMITED, LONDON ENGINEERS

(For description see page 650)

POWER HOUSE AT FORMBY



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TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

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REPLIES.

A. S.—Many firms now take learners without premiums. Apply by letter to any works which you think suitable, and particularly use any personal influence you may have to get an introduction to a director or manager.

PERPLEXED.—Are you convinced the admission valve is quite tight? The defect has all the appearance of being due to a leakage of the burning gases past the valve into the admission pipe. Grind it in hot and try a stronger spring. We presume you are satisfied that the timing gear is working properly, and that there is no loose contact or any defect of that kind.

MEETINGS NEXT WEEK.

INSTITUTE OF SANITARY ENGINEERS.—Friday, July 6th, and following days, at Manchester. Summer meeting. Sir Wm. Mather, M. Inst. C.E., will preside, and a very interesting programme of discussions and visits has been arranged.

DEATH.

On the 22nd June, killed in railway accident near Glasgow, ARTHUR COOTE, director of Messrs. Hawthorn, Leslie, and Co., Newcastle-on-Tyne, and 8, Kensington Park gardens, London.

THE ENGINEER.

JUNE 29, 1906.

The Webb Compound Locomotive.

AN interesting correspondence is proceeding in our columns concerning compound engines on the London and North-Western Railway. It will be remembered that in our obituary notice of Mr. Webb we criticised the design and performance of a large number of express locomotives which he had built during the latter twenty years of his service as chief mechanical engineer of the line. To these criticisms "F.A.L." took exception. To "F.A.L." another correspondent, "Lynx," replied last week. We regret that their letters should have touched upon Mr. Webb's character and behaviour, and we ask them and any other correspondents to bear in mind that the subject for discussion is not Mr. Webb but the locomotives on which he pinned his faith.

It is a noteworthy fact that no railway authority in Great Britain and Ireland ever believed in these engines; Mr. Webb, and Mr. Webb only, had faith in them. Precisely on what evidence that faith was based we have never been able to discover. Let us consider what the Webb system was and how it worked out in practice. The theory of it was that, given two independent engines, one high pressure with two cylinders, and the other low pressure with one cylinder, they would naturally "get into step," to use an electrician's phraseology, and would consequently use steam to the best advantage, all the pressures adjusting themselves. No combination of this kind has ever been successfully attempted at sea or for stationary purposes. It might have answered with a locomotive if only the two pairs of driving wheels were really detached from each other; but they were not. A little reflection will show that they were always partially coupled by the rails. If the engines got out of step they could only get in again by the slipping of one pair of the driving wheels. It has been stated that slipping constantly went on when the rails were in the least greasy, and tires suffered accordingly. The high-pressure pistons always ran against the intermediate receiver pressure, but that receiver was very small. The distribution of work might very easily become anything but equal; but what was much worse the draw-bar pull was irregular, because the cranks did not maintain the best angular and torque relations; while the reciprocating momentum stresses, instead of compensating for each other, were free to do all the mischief they could. It is, of course, indisputable that the theory of the engine was very pretty. To get rid of side rods was no small gain. It was worth something to dispense with a separate starting valve. But the theory did not work out in practice. The idea that a heavy train could be started with certainty by a single pair of 13in. to 15in. cylinders acting on a single pair of driving wheels was a delusion. But until this pair of wheels revolved the low-pressure cylinder got no steam. Starting depended very often on the slipping of one pair of wheels; but even if the low-pressure crank was on a dead centre nothing was gained. The intermediate receiver became choked with steam, and there was simply a dead-lock. On the other hand, if the low-pressure cylinder could get steam at all, it got it with a vengeance, and the starting of a train drawn by a Webb compound was an exceedingly unpopular experience with passengers. We may add that so far as we are aware no consecutive diagrams taken over, say, a 50-mile run, from all three cylinders of one of these engines has ever been published. Such a set would tell the world at once what went on in the cylinders, and how far the engines did or did not keep step. Possibly our correspondent "F. A. L." possesses such a set, and may be disposed to send them to us for publication. That the engines were bad starters is simply notorious, yet that they could do good work on long runs may be fully and freely admitted. But, after all, this is really only one of the points at issue.

The first consideration with the locomotive superintendent is to work the traffic with certainty and punctuality. Every other consideration sinks into insignificance in the sense that nothing must be permitted to interfere with the conditions laid down by the traffic manager. But punctuality ensured, it behoves the locomotive department to seek economy. Now economy in the use of steam is tantamount to an increase in boiler power, and it may very well happen therefore that punctuality is promoted or even secured by economy. We cannot call to mind that anyone outside an exceedingly limited circle ever held that the Webb compound was much better than any other locomotive, either as a machine or a vehicle. It was not a cheap engine either to make or maintain. The only advantage that it possessed would obviously be economy of fuel. No one, it seems, has ever been able to get at any detailed trustworthy statement of the reduction in haulage expenses secured by the introduction of the Webb compound. With the assertion that the consumption of coal was reduced some 12 per cent. the world is familiar. That, indeed, appears to be the normal saving effected by all compound locomotives. On the other hand it is well known that Mr. Webb was not able to reduce his grate surface; and the "Dreadnoughts" had the largest fire-boxes ever used on the London and North-Western. If any of our correspondents can supply trustworthy information on this point, they will do very good service. It would then become possible to establish a comparison between the Webb engine and a three-cylinder compound with the driving wheels coupled. The only important element of difference would be the coupling rods. If it can be shown that there is much loss due to the coupling rods, then it must be worth while to try a four-cylinder compound, each pair of cylinders, high and low, working one pair of driving wheels, no coupling rods being employed.

We cannot quite agree with the opinion sometimes expressed, that because a particular type of machine has gone out of date it is no longer worth while to write or speak about it. The Webb engine was in all respects original. Its use constituted a very great experiment. Nothing that its inventor could do to make it a success was wanting. The performance of the engines was carefully watched. One was tried by Mr. Stirling on the Great Northern. We have always heard that it failed to keep time. The first failures were said to be due to the grate bars being unsuitable to the Great Northern coal. So Great Northern bars were fitted, but the result was the same. One was sent to the United States, but it did not find favour. That the engines could do fine work was proved by the splendid performance of the "Jenny Deans." Nothing, we believe, militated more against the whole design than the impossibility of finding out whether the compound system did, or did not, effect a reduction in the cost of haulage. "F. A. L." was apparently behind the scenes. We look to him for some authoritative information on this question.

Steel in Theory and Practice.

STEEL in theory, regarded from one point of view, is a material so untrustworthy that its use cannot fail to involve many risks. In practice these risks are incurred, and nothing very dreadful happens. The theory is based on the results obtained in the testing machine, backed up and enforced by rare breakages more or less inexplicable. Practice is based on the fact that, in spite of the teaching of the laboratory, and a few unpleasant episodes, steel has proved itself an excellent constructive material, cheap and trustworthy. Opinions as to the merits and demerits of steel have fluctuated for many years. No sooner was a question about it answered than another cropped up. But it is well to remember that enormous weights of steel are in use, and that its failures have been, on the whole, in practice very few and far between. Furthermore,

in almost all cases they have been sensational; and for that reason have attracted a great deal of attention. If a wrought iron piston-rod broke, and two or three lives were lost, the catastrophe would be accepted without much remark as a thing to be expected; but if a steel rod breaks, the matter is talked about from one end of the country to the other. The mental attitude of a considerable section of the engineering world with regard to steel is peculiar, and not very easy to explain. There is a fluctuation of opinion continuously going on, and our purpose at present is to draw attention to a change in the way in which some steels are regarded which is full of interest.

Hitherto ductility has been regarded as an essential quality in all steels, and particularly in those submitted to dynamic stresses. It is clear that in a railway bridge, or floor or roof girder, the stress being invariably inside amounts far within the elastic limit, ductility can only have an indirect value. But for machinery subject to rapidly alternating stresses the conditions and environment are so different that ductility ought to be of immense value. If we come to examine the idea at the root of this hypothesis, we can express it in very few words—it is better that a part of a machine should bend than break. There is no answer in the negative to this proposition. It is manifestly and axiomatically true. The natural deduction is that the steel should be ductile and not "brittle"; and to secure this quality most engineers specify the chemical constitution of the metal, as well as the tests which specimens shall withstand. Roughly speaking, sulphur, phosphorus, and silicon are kept down to very small percentages. Carbon is strictly conditioned in quantity by the purpose to which the steel is to be put; and the breaking strength varies between 28 and 35 tons on the square inch, with extension percentages of 23 to 30, and bending tests of considerable severity.

Such tests as these pay no attention to the purpose for which the steel is to be used. Whether it is a boiler plate, or a piston-rod, or a girder plate, the test is the same in character. Recently we have had the impact test introduced, which it is well known has condemned many steels as bad, which, nevertheless, have been in practical use for long periods without accident. The result of much that has been written and said within the last few years is a revulsion of feeling among many mechanical engineers; and doubt is now being cast on the necessity for extreme ductility. It is argued that when fractures take place, in engine work let us say, the broken parts have not stretched at all. In other words, ductility is a factor which may be disregarded. It never appears to have any chance of manifesting itself usefully. When a boiler bursts the plates break up like glass. If a furnace crown comes down the ductility which permits its descent is due to the red heat of the plate. Whatever may be the cause of fracture, so far as can be known the quality of ductility is no safeguard, the most ductile metal in the laboratory or the testing-house breaking just as readily and just in the same way as that which is brittle. Be the explanation what it may, it is clear that "test-house stretch" is not indefeasible evidence one way or the other as to the fitness or not of a given steel for use, say, in a connecting-rod; yet it would be difficult to induce any ordinary engineer to give it up. It possesses the great value that, let what will happen in the way of destruction of life or property, the designer can say that he had taken every possible precaution to avoid an accident.

There is, however, another way of looking at the whole question. There is no certainty that the tensile test secures safety, while it involves the use of a material comparatively weak. Why should not a high steel be used instead of a low steel, a much higher factor of safety being adopted, even though the weight used is much reduced? It must be carefully borne in mind that we are not now speaking of vanadium steel, or any other exceptional alloy. The makers of motor cars, at all events, see no reason. They are using 60-ton steel for crank shafts, connecting-rods, and, in fact, in every part of the engine submitted to exceptional stresses. Why should engineers cling to a 30-ton steel that cannot bear shocks any better than a 60-ton steel, particularly when the results obtained in practice more than justify the employment of high steel for crank shafts and such like? Of course, it may be argued that what will do on a small scale will not do on a large scale, and to this argument we have no direct answer to suggest. The indirect reply is that, so far as can be seen, the soft ductile steel is not more trustworthy, but less trustworthy, under the conditions than the hard steel, while the use of the latter permits of achievements in the combination of lightness and power which with weaker metal would be impossible. If we push this inquiry into the region of alloys, we shall find further evidence of a new departure. There is now in the market a vanadium steel with an ultimate strength of 100 to 110 tons, an elastic limit of 93 tons, and a stretch of 13 per cent. in 2in. Another crank-shaft steel, probably chrome, is 71 to 77 tons, elastic limit 60 tons, elongation 13 per cent. These are, of course, crucible steels. But it must be remembered that very large masses of crucible steel can be had for the asking—at a price.

Regard the matter as we may, we cannot shut our eyes to the fact that men making most beautiful machinery, exposed to most violent stresses—machinery whose failure may cause disastrous breakdowns—are deliberately using a metal which large numbers of engineers still pronounce quite unsuitable for the intended purpose. No one seems to know why a steel is or is not brittle, and on the whole it seems to be better policy to use a very strong rather than a tolerably weak metal. Perhaps, after all, the favour which low steel enjoys may be more a matter of prejudice than common sense. If it could only be proved that this was the case, and that a 60-ton steel was as safe as a 30-ton steel, the construction of machinery, particularly for marine work, would be revolutionised in some respects. That those having authority do not stand in the way is a reassuring fact. Lloyd's draw no hard and fast line, and will accept any steel for crank shafts if good reason is shown. The Marine Department of the Board of Trade has gradually raised the limit for crank shaft steel from 30 tons to 40 tons, with 20 per cent. elongation in 10in. The facts as they stand add another complication to the steel question, and the result of what is in effect, a policy certainly novel in the extent of the practice which is its embodiment, will be regarded with interest, as it may have very far-reaching results. That high steels have been used sporadically in the construction of machinery is nothing new; the fact of their extended use on a large scale is quite a different matter.

Inasmuch as the policy of motor car builders is, we have reason to think, very far from being generally known, we may say that particular qualities of steel are used for every particular part of a car. What answers for gearing will not do for crank shafts. But one strictly original departure deserves special mention. As a rule, when a shaft breaks, engineers will replace it with one of larger dimensions; but certainly one Coventry firm has found that the way to prevent fractures is to use smaller, not larger, shafts, and a better steel. Steel can be had now with a breaking strength of 110 tons, and considerable ductility. Crank shaft steel is regularly made with a breaking strength of 90 tons, an elastic limit of 70 tons, and an elongation of 18 per cent. in 2in. With such facts before us, is it not absurd to continue the use of a material not one half as strong? Is not the mechanical engineering world shutting its eyes to the enormous developments that have taken place in steel manufacture. Is it not evident that the advantages possessed by 30-ton steel over 60-ton steel are theoretical? The whole problem of the use of steel in the construction of machinery demands careful revision in the light cast upon it by recent practice. Of course increased strength means less weight, so that first cost need not be augmented, although a better quality of steel was used. We are, moreover, very far from advocating a sudden jump in marine work—for instance, to a 90-ton steel. But we think that Lloyds and the Board of Trade would do well to reconsider some of their rules and regulations.

The Efficiency of Steam Plant.

Two papers, discussing the efficiency of steam engines and boilers, were read in London upon Friday, the 22nd inst., at the eleventh annual meeting of the Incorporated Municipal Electrical Association. The first of these papers dealt with the use of live steam for heating the feed-water of boilers, and was contributed by Mr. George Wilkinson, chief electrical engineer, of Harrogate. The live steam feed heating apparatus used in these experimental trials was constructed by Messrs. Dales and Braithwaite, of London, and is based upon the principle of spraying the feed water into a chamber which is connected with the steam portion of the boiler. This system of pre-heating differs from the much-discussed thermal storage system of Mr. Druitt Halpin, in that all the feed-water used in the boiler is passed first through the economiser and then through the live steam feed heater, and is thus raised nearly to the steam temperature before it enters the boiler. The experiments made at Harrogate by Mr. Wilkinson were carried out with an ordinary type Lancashire boiler, provided with a Green type of economiser of 288 pipes. The economiser alone raised the feed to a temperature ranging from 213 deg. Fah. to 265 deg. Fah. The Dales and Braithwaite apparatus added from 83 deg. Fah. to 120 deg. Fah. to this temperature, and the feed-water in these experiments could thus be raised to a temperature ranging from 333 deg. Fah. to 348 deg. Fah. The temperature of the steam during these tests of the live steam feed heater was between 353 deg. Fah. and 360 deg. Fah. Six steam-raising tests were made during the trials of this system at Harrogate—one with cold water feed, two with economiser feed, and three with both the economiser and the live steam heater in operation. The results showed a gain of 12·7 per cent. in the combined efficiency of the plant, when the live steam heater was in operation, and the consumption of coal was at the rate of 27·31 lb. and 29·53 lb. per square foot of grate area per hour, while at a lower rate of fuel consumption the gain by the use of the live steam feed heater was 7·0 per cent. If the tests carried out by Mr. Wilkinson are correct—and we see no reasons to doubt their accuracy—the gain in the thermal efficiency of a boiler by use of a live steam feed water heater, has been clearly proved under working conditions.

The claims made by Mr. Druitt Halpin, by Mr. Hamilton, by Messrs. Booth and Kershaw, by Colonel Crompton, and by ourselves, for the advantage and economy of hot feed-water are therefore at last likely to receive recognition and application, from the branch of the engineering profession engaged in the generation of electricity. Perhaps the most suggestive portion of Mr. Wilkinson's paper, however, is that in which he asserts that a much higher evaporative duty than at present is usual, may be obtained from steam boilers by the use of hot feed-water and rapid combustion. He considers that a coal consumption treble or quadruple that at present considered good work is possible with a boiler plant properly designed and equipped for the new system of working. A method of trebling or quadrupling the steaming power of their present boiler plant by comparatively simple means, would thus seem to be within reach of all steam users. We hope Mr. Wilkinson will follow up this suggestion by carrying out at Harrogate some tests of the live steam feed heater, with still higher rates of fuel consumption than the 29·5 lb. per square foot of grate area given in No. 4 of his boiler tests. A boiler with a specially large fire grate and combustion chamber would be required to give this method a fair trial, but the cost of providing this would be saved, we believe, in the reduced consumption of fuel, one of the most interesting of Mr. Wilkinson's observations being that at these high rates of combustion the whole flue space of the boiler becomes filled with incandescent gas. A considerable portion of Mr. Wilkinson's paper is devoted to the theoretical side of the subject, and an attempt is made to answer the question, "Why should a boiler show a higher thermal efficiency when fed with water at or near the temperature of ebullition?" The experiments of Sir William Anderson, Sir Frederic Bramwell, Miss Bryant, Mr. Dales and Mr. A. W. Hamilton, are referred to in this connection. These all prove that the higher the temperature of the water on the one side of the boiler plate, the greater is the rate of heat transmission from the source of heat on the other side of the plate, and that the maximum of heat transmission occurs during ebullition. Many theories have been advanced by boiler engineers and others to account for this fact. The theory which finds most favour with the author of the paper we are discussing is that, at the moment of its conversion into steam, the water takes up from the plate with great rapidity the whole of the thermal energy represented by the latent heat of steam—or about four times that required to raise the temperature of the same volume of water from 0 deg. Fah. to 212 deg. Fah. Therefore, at those portions of the boiler where ebullition is occurring, the rate of heat transmission must necessarily be much higher than at those portions where water is being raised to the ebullition point. The objection usually advanced to meet this theory is that the production of steam from water at the temperature of ebullition, does not occur instantaneously at the surface of the plate. A small bubble of steam forms here, it is true, but this detaches itself from the plate almost as soon as it is formed, and as it rises up through the heated water it gains enormously in size. The formation of steam is occurring, in fact, at all stages of its upward journey, and not only at the surface of the boiler plate—and this formation of steam and absorption of heat only ceases when the bubble arrives at the surface of the water and escapes as wet steam. Another objection to the theory advanced by Mr. Wilkinson is that, if true, boilers would produce steam with almost explosive violence, for all the water in contact with the boiler plates would be converted into steam instantaneously. A theory which is proof

against all hostile criticism has, in fact, yet to be formulated, and it would be of much assistance in this matter if one could construct a high-pressure boiler of glass or of some other transparent material, which would allow one to see what was occurring during ebullition. Until this is done, we fear the exact cause of the gain in thermal efficiency of boilers fed with water at the temperature of the steam will remain unexplained. However, while we thus dismiss the theoretical side of Mr. Wilkinson's paper as of little value, its practical importance is great.

Mr. Walter A. Vignoles, the author of the second paper, is Chief Electrical Engineer of Grimsby, and his paper, entitled "The Efficiency of Steam Plant," is an attempt to explain why the coal consumption is much higher in central generating stations than in marine work. Upon the subject of boiler house economy Mr. Vignoles has nothing novel to say, and as he evidently never makes any tests either of his fuel or of his waste gases, we cannot regard the plant under his charge as one which is being worked to the fullest advantage. The figures given in Table IV. of Mr. Vignoles' paper confirm this opinion. Under "Plant Economy," Mr. Vignoles tabulates the results of tests made at the Grimsby Works, showing the extra steam consumption due to the stand-by and other losses. These losses, and the diagrams given in Mr. Vignoles' paper, are chiefly interesting to electrical engineers, but his remarks concerning the wasteful steam consumption of the auxiliary engine plant have a more general application. In the tests made at Grimsby Mr. Vignoles found that the auxiliaries consumed 5·1 lb. of steam per kilowatt-hour, as compared with 31·6 lb. for the main engines. Thus, nearly one-seventh of the steam generated was used for the auxiliary engine plant. Mr. Vignoles recommends the use of electrically-driven pumps in order to reduce these losses.

The two papers which have been discussed above show that electrical engineers are taking an intelligent interest in their steam-raising plant, and are beginning to understand more fully than before that it is in the boiler-house, rather than in the dynamo room, that the greatest scope for improvement and economy lies. Messrs. Booth and Kershaw, in their paper entitled "Fuel Economy in Steam Power Plants," read before the Institution of Electrical Engineers in January, 1905, emphasised the importance of the boiler in the economical generation of electricity, and suggested experiments upon the lines of those carried out by Mr. Wilkinson at Harrogate. It is obvious that both Messrs. Wilkinson and Vignoles have been close students of that paper.

Greenwich Observatory and the County Council.

"A GIGANTIC mistake has been made—a mistake by the Admiralty, by the Astronomer Royal, by the County Council, and by Parliament." In was with these words that Lord Goschen concluded his speech on June 20th, when the questions at issue between the Astronomer Royal and the London County Council were under discussion. There can be no doubt that the prospect of the scientific investigations at Greenwich being impaired, if not altogether paralysed, is a matter of national, if not world-wide importance. It is no mere æsthetic objection that is being taken by those who are interested in the Observatory to the proximity of a large generating station, but a very real one, it appears not improbable that serious interference must result if the generating station is used.

Two or three facts may serve to show how delicate are the instruments and apparatus which are used at an Observatory, and how easily they may be upset by outside influence. Take, for instance, the artificial horizon which is placed under a meridian circle, and is used for the purpose of ascertaining whether the axis of the instrument is exactly horizontal, or, rather, for correcting any error to which the instrument may have become subject. This artificial horizon is nothing more elaborate than a bath of the purest mercury, but the smallest degree of vibration is sufficient to set up tiny waves on its surface and render it useless. At the Dunsink Observatory, near Dublin, the observers often found that they were unable to use the horizon with any degree of accuracy. The reason was far to seek. About three miles away from the Observatory—which is built on limestone—runs the Irish Great Western Railway, and it was discovered that the vibration caused by the passing trains was sufficient to account for the disturbance. If a railway train passing at so great a distance is a source of trouble, what shall be said of a generating station which, when complete, is to produce 52,000 horse-power, and is only removed from the Royal Observatory by a distance of a quarter of a mile? Vibration, however, is not the only mischief to be feared. The generating station is bound to produce large quantities of smoke and vapour. It is plain to the meanest intelligence that volumes of black smoke in the neighbourhood of an Observatory are likely to cause interference with observations, especially at Greenwich, where the the atmosphere is none too translucent at the best of times. But the astronomer is worried almost as much by invisible vapours. A column of hot air ascending in the front of the object glass of a telescope is fatal to the view. Visitors to an Observatory are often surprised that the "dome" is never heated by artificial means, and that the astronomer who must keep a vigil on a winter's night must do so all wrapt in furs. The reason why no stove can be placed in the "dome" is that it might cause a current of slightly heated air to ascend and pass out through the open shutter and in front of the objective. But there are other hot air currents which are also productive of damage, and are not under the control of the astronomer. There are other movements in the higher regions of the atmosphere which render it impossible for the astronomer to use his full power. To all appearances the night may seem to be an ideal one from the astronomical point of view; yet the influences above mentioned may be at work to distort the field of vision. It follows that although the chimney stack of the new generating station may emit no visible smoke, the fumes of a clear furnace at the County Council station may be disastrous to the neighbouring Observatory.

The fact of the interference of the generating station with the work of the Observatory being granted, the question arises as to the best method of correcting the mistake. Let us first consider the rights of the Astronomer Royal and the possible liabilities of the County Council in this matter. It is provided by every tramway order that "nothing in this order shall exonerate the promoters from any indictment, action, or other proceeding for nuisance, in the event of any nuisance being caused or permitted by them upon any land acquired by them." It is even within the bounds of possibility that the Court would grant an injunction. It may not be a question of damages. Thus it was laid down by the late Lord Justice A. L. Smith that: "Damages in substitution for an injunction may be given (1) if the injury to the plaintiff's legal rights, is small; (2) is one which is capable of being estimated in money; (3) is one which can be adequately compensated by a small money payment; and (4) the case is one in which it would be oppressive to the deputant to grant an injunction. There may also be cases in which, though the four above-mentioned requirements exist, the defendant by his conduct—as, for instance, hurrying up his buildings so as if possible to avoid an injunction, or otherwise acting with a reckless disregard to the plaintiffs' rights—has disentitled himself from asking that damages may be assessed in substitution for an injunction." On the other hand, there may possibly be some question as to whether the Astronomer-Royal would be entitled to a special meed of protection under the ordinary law, inasmuch as the damages which he fears he may sustain are due to the particular and somewhat extraordinary use which he is making of his own land. Apparently, however, this defence cannot avail the County Council, for the Observatory has been given special protection by the Act passed in 1902, which provides that where the use of electric power acts, or was likely to act, injuriously on any instrument or apparatus used in any Observatory or Laboratory under the control of the Board of Trade, the department should have power to require reasonable and proper precautions to be taken. Apparently the choice of a site lay to some extent with the County Council, and without reckoning how serious a step they were taking, they deliberately chose the position now occupied by their generating station. But how they were allowed to carry the work to the position it has now reached, is a question which both they and the directors of the Observatory will have to answer.

However, since the destruction of the work of the Observatory cannot be measured in money, any question of compensation for harm done is almost beside the point, unless, indeed, the removal of one or other of the establishments should be found unavoidable, and we trust, however, that the resources of science and engineering may be potent enough to find some less extravagant path out of the difficulty. The chimneys could certainly be done away with or removed to such a distance that they would rarely or ever interfere with the invaluable work of the Observatory. Means too may be found of arresting vibration before it has reached the artificial horizon. But if all such steps should fail, and the station should interfere with the work that the Observatory has carried on for so long, the sympathies, not only of all England, but of the whole world, will be on the side of the Observatory.

Highgate Tramcar Accident.

ON Saturday afternoon last a serious accident occurred at Highgate owing to the driver of an electric tramcar losing control of the vehicle. The runaway car belonged to the Metropolitan Electric Tramways Company, Limited, whose system extends from Whetstone to Holloway. Considering the nature of the accident, the time, and the locality in which it took place, there was, happily, a very small death roll. All the passengers escaped death, but, unfortunately, owing to a Vanguard motor omnibus being forced on to the pavement by the impact of the errant car, three persons lost their lives, and about twenty-seven people were more or less seriously injured. The scene of the disaster was on the steep gradient connecting Holloway and Junction-roads with that portion of the Great North road known as Archway-road, Highgate. The exact cause of the accident is not known, and, indeed, is not likely to be officially stated until after the Board of Trade inspection of the damaged car. Sufficient evidence was, however, given at the inquest on the unfortunate victims by the driver, Ernest Henry Cone, to leave little doubt as to the real cause. It appears from his evidence that before he reached the hill on which the mishap took place he had already had trouble with the braking of the car. At the Highgate Police-station he had been unable to stop owing to the wheels skidding on a slippery road, and although he took off the hand-brake the wheels failed to revolve. This statement is probably the most important in the evidence. If it be true—and we have no reason at all to doubt the veracity of the driver's statement—it shows that there must have been some defect in the running gear of the car, or that the brakes remained on, although apparently released. Of these two alternatives the first can probably be dismissed at once, owing to the subsequent behaviour of the car. The second is the more likely cause of the disaster, although it is difficult to understand how such a condition could arise. One thing, at least, is certain, the wheels were locked, and the driver was unable to release them. Unfortunately, unless the wheels revolve the magnetic brake is useless. There appear to have been only two brakes on this car. These presumably were considered sufficient, or the Board of Trade would not have passed them. This plan works well, as long as the drivers are careful, to check the speed of the car by the magnetic before applying the hand brakes. This, however, it is difficult to teach them to do, and in spite of instructions they frequently use the hand brakes when descending hills. It does, moreover, seem rather inconsistent to have two brakes so placed that if one fails through the most likely channel—the locking of the wheels—then the other is inoperative. This system is admittedly adopted by nearly all tramways, but in hilly districts an emergency slipper brake which acts on the rail is also used. For the obvious reason that the trolley may leave the wire and so cut off the current, it is desirable that such brakes should be applied mechanically, as in the case of Halifax, where very steep hills have to be descended. With the combination of these three brakes tramcars have been running for years, without having any accident, in districts which have hills and other conditions far worse than any to be found in the metropolitan area.

Conference in the Engineering Trade.

THE Engineering Employers' Federation has, we are informed, agreed to the request of the Amalgamated Society of Engineers, the Steam Engine Makers' Society, and the United Machine Workers' Association to hold at an early date a conference to reconsider the terms of settlement which were jointly adopted after the great strike, and which have been in force since January, 1898. We are not in the position at the present time to give in any detail the proposals which the unions intend to lay before the employers, but they refer to the limitation of the total number of hours of overtime worked per month; to the limitation of apprentices; and, finally, to the position of unionist workmen. These are all old causes with which numerous struggles have made us familiar. Of the three, the last is the most serious. We cannot give the precise terms of the demand, but, broadly speaking, it is that unionist workmen are to be given the preference of employment over non-union men. Whether the conditions which accompany this request so modify it that the employers can agree to it without hampering their interest or sacrificing their freedom remains, of course, to be seen. But that the unions are determined to press the demand to the utmost

is unfortunately a fact, and there is, therefore, some danger of disturbance in the trade. We trust, however, that before the conference nothing will be said or done to inflame the feeling on either side, so that the meeting may be as friendly and conciliatory as many that have been held between capital and labour in the engineering trade during the last few years. Labour has now its representatives, who take some share in the management of the country and the Empire, and the sense of responsibility which attaches to that high duty will, we earnestly trust, direct them to do nothing which may seriously hamper one of our most important industries. That they have any real grievance it is difficult to believe in the face of the fact that, on the whole, harmony has prevailed since the signing of the 1897 agreement.

RAILWAY ACCOUNTS.

As briefly stated in our issue of the 23rd inst., a Departmental Committee has been appointed by the Board of Trade "to consider and report what changes, if any, are desirable in the form and scope of the accounts and statistical returns—capital, traffic receipts, and expenditure—rendered by railway companies under the Railway Regulations Acts."

The Committee consists of Mr. A. Clayton Cole, chairman; Mr. W. M. Acworth; Mr. W. Bailey, chief accountant of the Midland Railway Company; Mr. G. Stapylton Barnes, comptroller of the companies' winding-up department of the Board of Trade; Mr. A. Wilson Fox, C.B., Board of Trade; Sir Chas. J. Owens, general manager, London and South-Western Railway; Mr. G. Paish, the Hon. George Peel, Mr. G. J. Whitelaw, chief accountant of the Great Western Railway; with Mr. H. Fountain, Board of Trade, as their secretary. Mr. Clayton Cole is a director of the Bank of England, and an authority on economic questions. He may, therefore, be regarded as an independent chairman. The representatives of the railways will commend themselves to the public as well as to the railway interest. Mr. Bailey, in particular, is an ideal member, as was proved by the excellent work he did for the railways and for the public when in Belfast as accountant to the (then) Belfast and Northern Counties Railway, and prior to his present appointment at Derby. Mr. Acworth is well known to our readers as an authority on the subject, and was one of the leading champions for reform in railway statistics. Mr. Paish, too, is known as an ardent reformer. He is one of the editors of the *Statist*, the author of "The British Railway Position," and one who has been for many years intimately associated with the financial aspects of American railways. The Hon. George Peel is the chairman of the Railway Investment Company, and a member of the Shareholders' Committee which have urged on the London and North-Western Company the need for more information as to details of expenditure and receipts.

The Committee had an informal meeting last week, when it was decided that they would commence taking evidence on Tuesday last, the 26th. They further decided that the proceedings would not be open to the public, and that a summary of the evidence would be published in their report.

The much debated subject of ten-mile statistics naturally arises in one's mind on hearing of the appointment of this Committee, but there are other points that will come under their review. It must be borne in mind that the companies are legally bound to furnish two returns as to their financial condition and business done. The first of these is for the information of the shareholders and the second is for the Board of Trade. The form and scope of the return supplied to the shareholders was laid down in the Railway Regulation Act of 1868. The return for the Board of Trade was fixed by the Railway Regulation Act of 1871. Their form was therefore adopted thirty-five to thirty-eight years ago, in the earliest days of railways, and they practically remain the same to-day as then. The Board of Trade possess powers to call for more information, as in the Railway and Canal Traffic Act, 1888, it was provided that "the returns required of a railway company under Section 9 of the Railway Regulation Act, 1871, shall include such statements as the Board of Trade may from time to time prescribe, and the forms referred to in that section may from time to time be altered by the Board of Trade in such manner as they may think expedient for giving effect to this section." The powers conferred on the Board by this clause have practically lain dormant, due, possibly, more to the want of pressure of public opinion than to the unwillingness of the Board of Trade to ask for it and of the railway companies to furnish it. Some very slight modifications have, however, been made, as, for instance, the mileage of track—single line of rails, double line, three lines, &c.—has been given for the last two or three years.

The half-yearly reports issued by the companies to their shareholders require considerable amendment and amplification. There is also no more need for the figures to be issued half-yearly than with other corporate concerns. A yearly report with an interim dividend should suffice. The complete figures for the year would then be available, and these would be easier of comparison. Without going through each table of a report seriatim, it may be remarked that more detail is required as to the capital authorised and created, the capital raised by loan and debentures, and the receipts and expenditure on capital accounts. More information should certainly be afforded as to rolling stock. Instead of only the number of tender and tank engines being given, the proprietors should have an idea as to the tractive power capacity of the locomotives, and in addition to being told how many of each pattern passenger vehicles the company possesses they should be informed of the seating capacity of same, and, similarly, the tonnage capacity of the wagons. Mr. Acworth, in a paper he read before the Royal Statistical Society on this subject in December, 1902, compared the methods adopted by the Pennsylvania Railroad with the British plan of supplying the figures for traffic expenses and general charges. The former on our railways consists of eight items:—Salaries and wages; fuel, lighting, water, and general stores; clothing; printing, stationery, and tickets; horses, harness, vans, provender, &c.; wagon covers, ropes, &c.; joint station expenses and miscellaneous expenses. General charges are comprised of:—Directors; auditors; salaries: secretary, general manager, accountant, and clerks; office, travelling and incidental expenses; advertising; fire insurance; electric telegraph expenses; Railway Clearing House expenses; and contributions to superannuation funds. On the Pennsylvania Railroad the traffic charges are divided into the following heads, each division—there are four divisions—having a separate table; the cost per year, and increase or decrease over the previous year following each item:—

Conducting transportation.—Superintendence; clerks, attendants, and office expenses; enginemen and firemen; roundhousemen; fuel for locomotives; expenses of fuel stations; water supply for locomotives; stores for locomotives; other supplies for locomotives; conductors, baggagemen, and brakemen; heating and lighting cars; cleaning cars; lubricating cars; other train supplies and expenses; yardmen; switch tenders and signalmen; watchmen; telegraph expenses; station agents and clerks; station labour; heating and lighting stations; signals and interlocking plants; expenses of operation and supplies; other supplies and expenses of stations; switching charges, balance; car mileage, balance; loss and damage; injuries to persons; clearing wrecks; barges, car floats, and canal boats, charters, incidentals, superintendence, and manning; elevation and longshore labour; steamboats and tugboats, charters, fuel for, incidentals, superintendence and manning; advertising; foreign agencies; stock yards and elevators; rents for tracks, yards, and terminals; rents of buildings and other property; stationery and printing; motormen and conductors; power houses, expenses of operation; yard and street lighting; insurance; incidentals.

General expenses.—Clerks; heat and light; office expenses and supplies; expenses of relief department; law expenses; stationery and printing, general office; advertising; incidentals.

It will thus be seen that what is generally the heaviest item in expenditure out of revenue, viz., the traffic charges, is very fully amplified. In our returns most of the items under the head "General Charges" should be divided amongst the expenses of the departments.

The annual returns sent to the Board of Trade under the Act of 1871 are built up in the same meagre way. That they can be supplied in greater detail we are satisfied. It is not a question of mere book-keeping, because the companies already possess the information. The proprietors certainly are entitled to the knowledge as to how the money they have invested has been cared for. It is true that in giving them this information it becomes public property. Some railway officers may object to giving their neighbours such information, but if legislation compels universal action, then what one officer considers he gives away is compensated for by the information he gains about his neighbours.

In this part of their labours the Committee will not have much difficulty in arriving at a decision as to what shall be recommended, but the heaviest task and possibly the real work of the Committee will come when they have to deal with the wisdom or fallacy of ton-mile statistics.

PISTON RINGS.

A NEW form of piston ring has been placed on the market by Messrs. P. A. Mudd and Co., of Church-street, West Hartlepool. Rings of this make have been applied to cylinders with diameters varying from 10in. to 100in., and with pressures varying from something quite low to high pressures with superheated steam, the highest pressures yet dealt with being in the high-pressure cylinders of five sets of quadruple-expansion engines with a boiler pressure of 267 lb. per square inch. The

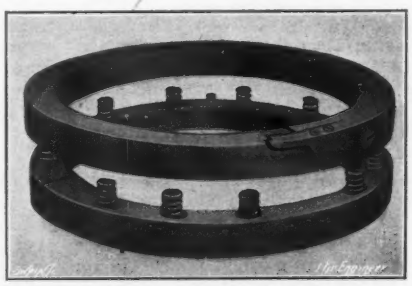


Fig. 1. MUDD PISTON RING

makers claim that a considerable experience with them has shown that these rings are perfectly steam-tight; that there is a remarkable absence of wear, showing that the friction is low; that there is no barrelling of the cylinders, and that the rings are easily examined and adjusted.

The rings are of cast iron and of rectangular section, and they bear upon a wide surface on the junk ring and piston flange. They have between them strong helical springs always tending to exert a pressure on the surfaces of the junk ring and flange. This pressure is made proportional to, and is designed to exclude, the steam pressure behind the rings, and tending to force them against the cylinder walls. This pressure being counteracted, it is only necessary in order to ensure steam-tightness to exert a small pressure against the cylinder walls. To obtain this pressure the rings are split, a small piece being cut out of each. They are then compressed, and in this condition they are turned to gauge. The pressure exerted by the rings against the cylinder walls is then adjusted

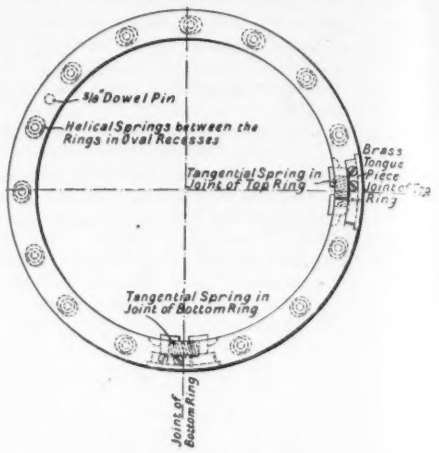

⅝"Dowel Pin
Helical Springs between the Rings in Oval Recesses
Brass Tongue Piece
Tangential Spring in Joint of Top Ring
Tangential Spring in Joint of Bottom Ring
Joint of Bottom Ring

Fig. 2

by means of a tangential helical spring fitted in the joint so that one man can move the rings in the cylinder, so slight is the pressure. Indeed, we are informed that when the rings are new the spring is only very slightly compressed. Then when wear has taken place washers are used to compress it just sufficiently to keep the rings steam-tight. The adjustment is said to be quite easy, and the rings to have a long life.

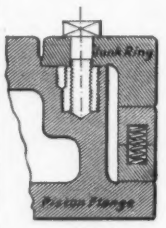


Fig. 3

A further feature claimed for the rings is that they are "floating," that is to say, that they are tolerably independent of the piston and follow the line of the cylinder walls, while the piston is free to follow the line of the guides. This quality, it is pointed out, is of high importance in connection with the preservation of the circular form of the cylinder.

The general construction of these rings is well shown in Figs. 1, 2, and 3, of which Fig. 1 is a perspective view, Fig. 2 a drawing showing the positions of the joints and the two kinds of springs, and Fig. 3 a sectional drawing showing how the rings are arranged with regard to the piston.

TEST OF A PUMPING ENGINE.

THE new pumping engine for the water supply of St. Louis has developed in the official test a duty of 158,851,000 foot-pounds per million British thermal units, or 181,068,605 foot-pounds per 1000 lb. of steam. This, it is claimed, is the highest duty record ever made by pumping engines, and earned for the builders the bonus of £9214, at the rate of £200 per million foot-pounds above the contract requirement of 135,000,000 foot-pounds. The engine was built by the Allis-Chalmers Company, who send us the following details:—

The engine is rated as of 20 million gallons daily capacity, and is of the vertical triple-expansion type, with single-acting outside-packed plungers directly under the cylinders. The engine is one of a set of three at the Bissell's Point high-service pumping station, and has steam cylinders 34in., 62in., and 94in. diameter, with 33½in. water plungers. The stroke is 72in.

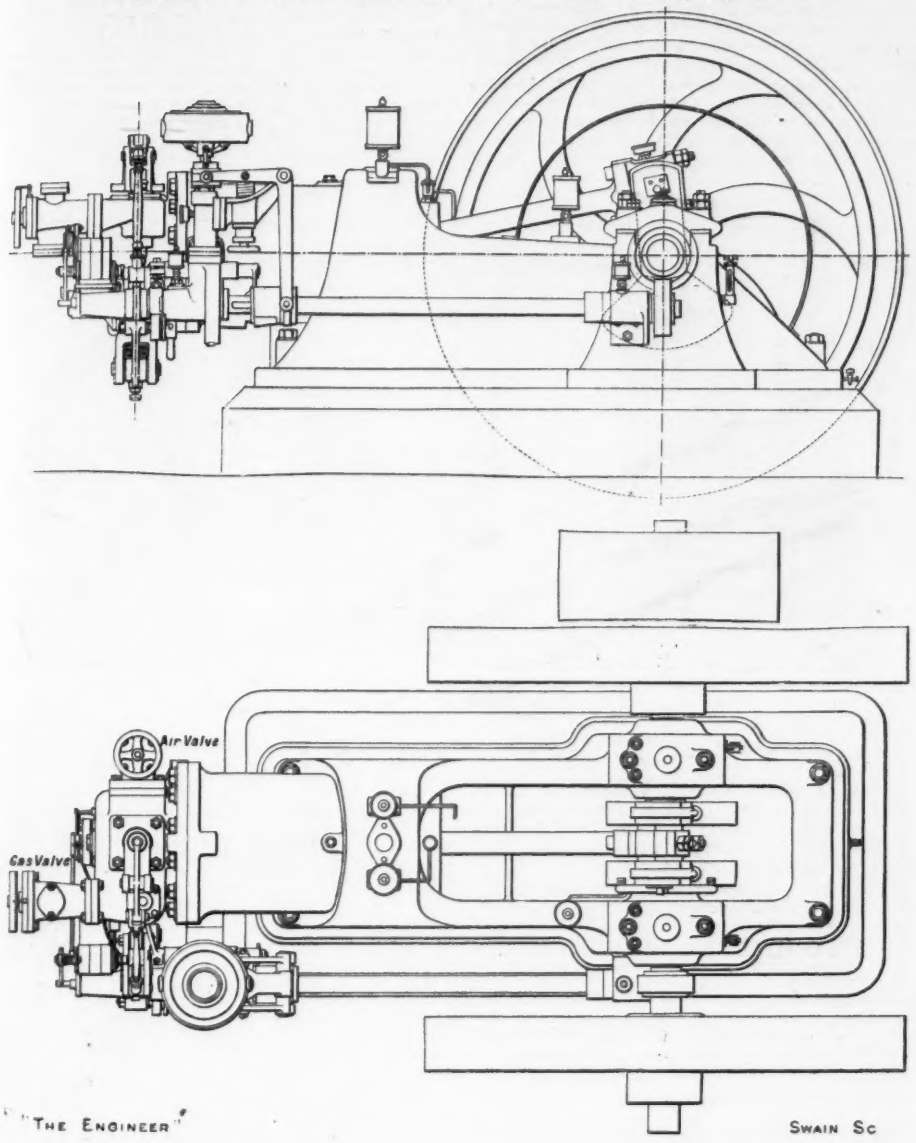
The official test was of twenty-four hours' duration, and before the start the water plungers were carefully calibrated by micrometer calipers and steel tape measurements of their circumferences. The stroke of each plunger was also measured, and all the pump valves were inspected and found tight under pressure. The head on the discharge main was read by a mercury column with scale graduated in feet, and the suction head was indicated by a float gauge. The contract required that, in order to determine the amount of steam used by the engine, the water must be weighed twice—that is, both the feed-water going in and the condensed steam coming out to be measured. The condensation from the condenser, cylinder jackets, receivers, and drips from stuffing-boxes was weighed as received from the engine and delivered at the boiler-room, and was found to check by 0·12 of 1 per cent. The general results of the test were as follows:—

Duration of test	24 hours
Diameter of steam cylinders	34in., 62in., and 94in.
Diameter of water plungers	33½in.
Stroke	72in.
Moisture in steam	0·13 per cent.
Average pressure at engine	140·24 lb.
" " at first receiver	26·36 lb.
" " at second receiver	2·77 lb.
Average vacuum pressure	13·24 lb.
Average barometer pressure	14·46 lb.
Average net head pumped against	238·2323ft.
Average head at discharge pipe	100·021 lb.
Revolutions per minute	16·539 revolutions
Piston speed per minute	198·440ft.
Total water pumped	20,070,690 gallons
Total water received from engine	220·129 lb.
Plunger leakage, per hour	16·77 gallons
Indicated horse-power	865·23 horse-power
Delivered horse-power	842·69 horse-power
Percentage of friction	2·60 per cent.
Average moist steam per indicated horse-power per hour	10·60 lb.
Average dry steam per indicated horse-power per hour	10·59 lb.
Average B.T.U. per indicated horse-power per minute	261·30 B.T.U.
Mechanical efficiency	97·4 per cent
Thermal efficiency	21·06 per cent.
Duty per 1000 lb. of steam	181,068,605 foot-pounds
Duty per 1,000,000 B.T.U.	158,851,000 foot-pounds

MOST of the sugar machinery in use in Peru is obsolete, and, according to the British Consul, requires to be renewed.

ENGINE FOR SUCTION PRODUCER GAS

THE RAILWAY AND GENERAL ENGINEERING CO., LIMITED, NOTTINGHAM, ENGINEERS



SUCTION GAS PRODUCER TRIALS.

No. III.*

THE general arrangement of the plant submitted by the Railway and General Engineering Company, Limited, of

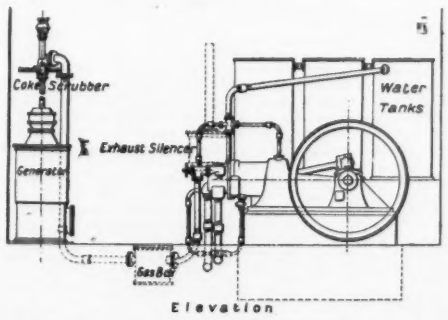


Fig. 15—RAILWAY & GENERAL ENGINEERING CO.'S PLANT

Nottingham, is shown in the illustrations, Figs. 15 and 17. This firm is using a Dowson gas generator in conjunction

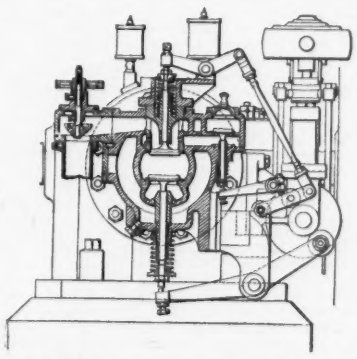


Fig. 16—INLET AND EXHAUST VALVES

with its "Midland" gas engine. The latter is illustrated above. It is designed to develop 20 effective horse-power at 170 revolutions per minute, when working on suction gas. The ordinary "Otto" cycle system has been adopted, and the speed is governed by a reducing gas cam which reduces the amount of lift of the inlet valve. The speed of the engine can be adjusted to suit requirements by means of a spring resistance. The cylinder is water-cooled, and is fitted with a separate removable liner made of specially hard metal. The arrangement of the inlet and exhaust valves is shown in Fig. 16. They are placed one above the other, and both open direct into the combustion chamber. The inlet valve is carried in a separate removable valve plug, thus allowing easy access to exhaust valve for examination and grinding purposes. A supplementary cam has been provided for opening the exhaust valve and easing the compression for starting the engine. The gas valve chamber is cast with a breech end. The gases pass through a port in the air valve chamber, and are thoroughly mixed with the air on each suction stroke of the engine. Gas and air cocks are provided for adjusting the mixture. Ignition is effected by means of a low-tension Fischer magneto machine. Considerable care has been bestowed upon the method of lubricating the various parts. The piston and piston pin are lubricated by means of sight-feed lubricators. The crank pin is oiled by a centrifugal oiling ring. The main bearings are ring lubricated, which keeps them always covered with a film of oil. Attention has also been paid to balancing the engine. Counterweights are bolted to the crank webs in order to counterbalance the revolving parts. Both ends of the connecting-rods have marine type brasses, which can be easily adjusted when wear takes place. The cylinder jacket is cast with the bed-plate. The breech end is bolted on to the cylinder, and is designed to reduce strains due to expansion. The bed-plate extends well under the cylinder, and provides an evenly distributed load on the foundation. The engine is provided with a self-starter.

The next engraving—Fig. 18—illustrates a section of the National suction gas producer made by the National Gas Company, Limited, of Ashton-under-Lyne. It is an interesting plant, possessing as it does some features which are not embodied in the other plants. The vaporiser consists of an internal cylinder A with an external cylinder B. The latter can be readily removed, when the whole of the inside of the vaporiser is exposed to view for examination. This arrangement will be fully appreciated by those who use suction gas plants in places where hard water only is obtainable, in which case the effective cleaning of the vaporiser is of the utmost importance to the effective working of this type

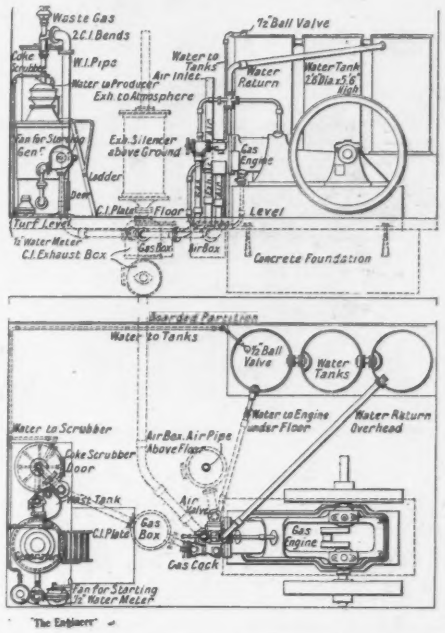


Fig. 17—RAILWAY & GENERAL ENGINEERING CO.'S PLANT

of power plant. Attention should also be directed to the method of distributing the water over the available heating surface of the vaporiser. An open cup C is formed at the top of the vaporiser, and V-shaped notches are cut in this cup at intervals. It is said that it requires practically all the notches to be put in operation to convey away the requisite water for vaporisation, with the result that when the water is poured into the cup-shaped trough at the top a portion overflows through each notch, and then falls down on to the ribs immediately below. The water spreads horizontally along the ribs, and as these are arranged with different widths, the widest being at the bottom, it is impossible for the water to drop from the top to the bottom of the vaporiser. It must either trickle down the sides or else drop from rib to rib. This arrangement is said to have proved to be most effective in practice, and to add greatly to the efficiency of the vaporising part of the plant. The generator works on the regenerative principle as far as possible. In order that the air which passes into the generator may always carry with it the requisite quantity of steam in suspension, it is desirable to pre-heat the air. This is done here by utilising the waste

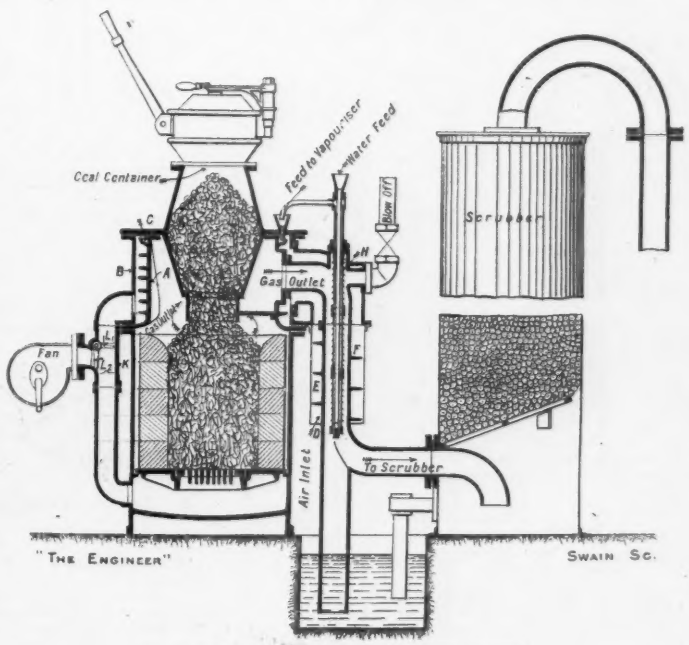


Fig. 18—NATIONAL GAS CO.'S SUCTION PLANT

* No. II. appeared June 22nd.

heat of the outlet pipe from the generator to the scrubber. This arrangement will be best understood by reference to the illustration. The pipe D has a number of vanes cast on it, and this portion of the pipe is encased. The vanes are so shaped that the air, which enters at the bottom, has to pass round and round the passages E and F, so that when it reaches the vaporiser its temperature has been raised considerably. In order to facilitate steam raising, the feed water enters at the top of a ribbed pipe H, which passes down the centre of gas outlet pipe from the generator, and so thereby heated to a high temperature before it passes into the vaporiser.

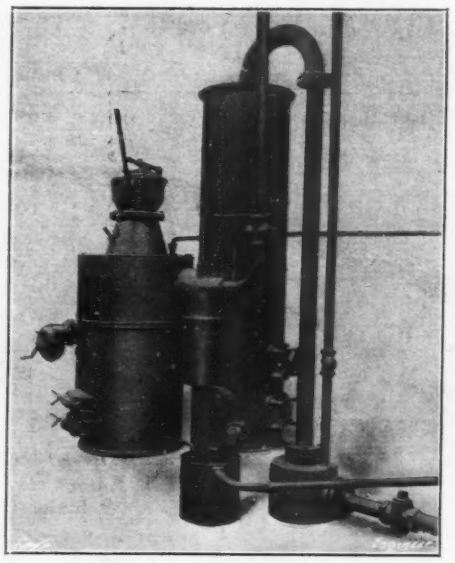


Fig. 19—THE NATIONAL PRODUCER

Another special feature of this plant is the manner in which the fan has been attached and is operated. It is fixed to a junction piece K on the pipe, which conveys air and steam from the vaporiser to the ashpit. In starting the plant the deflector L is moved into the position L^1, whilst when working it occupies the position L^2. By this means the usual cocks and blank plates have been dispensed with. The gases are cleaned and cooled by being passed through an ordinary coke scrubber, and are taken direct from the top of the scrubber to the engine. An illustration of the complete plant is given in Fig. 19.

Kynoch's Limited, of Lion Works, Witton, near Birmingham, are competing with the plant shown in Figs. 20 and 21. The makers appear to have paid particular attention to making all the parts easily accessible for cleaning. It does not work on the internal vaporiser principle, but has a separate boiler between the generator and the scrubber. The generator is of the usual construction, consisting of a metal casing lined with firebrick. The hopper is fitted with a valve, which is operated from outside. Fuel is placed in the hopper and the cover replaced, then by lowering the lever *i* the coal drops into the fuel container. The vaporiser consists of a hollow pipe, on the outside of which is cast a spiral groove. The gases pass from the furnace through this pipe, imparting the heat to the sides. Water is allowed to trickle on to the groove at the top, and before reaching the bottom it has been converted into steam by the heat of the gases passing through the pipe. Air is admitted at *x*, and this mixes with the steam, the mixture being drawn through K, and up through the grate into the furnace *a*. The scrubber is similar to most of the others. The gas leaves it at the top and before entering the engine it passes into an expansion box 19. The plant is arranged to work on anthracite, gas, coke, or charcoal. It is of simple construction, and there are no internal pipes or vaporiser. Everything is external, and easily accessible.

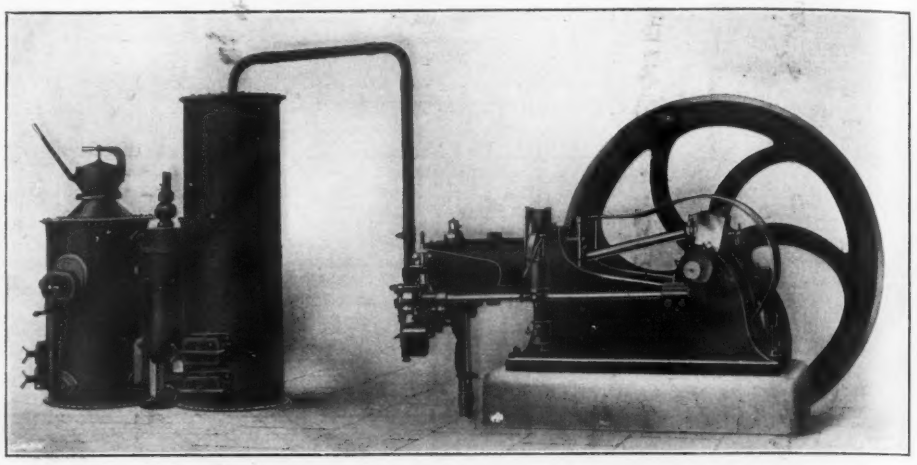


Fig. 21—VIEW OF KYNOCH'S COMPLETE INSTALLATION

The awards were published on Wednesday at the showyard, but the judges' report will not appear for some time. The gold medal was gained by the National Gas Engine Company's 20 horse-power plant, and the silver medal by Crossley Brothers' 15 horse-power plant.

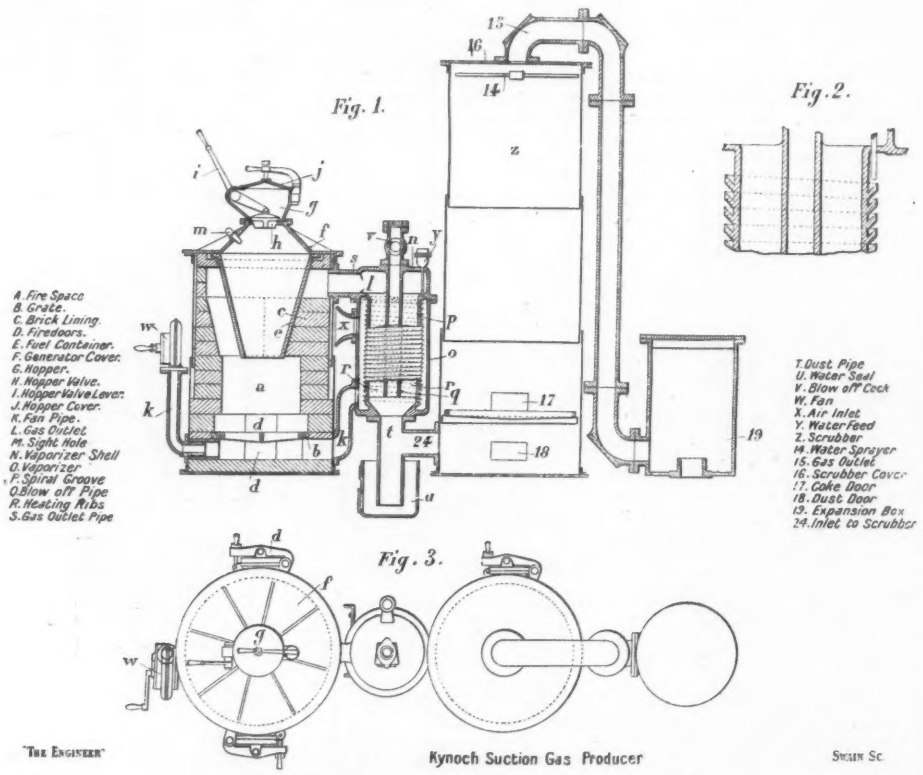


Fig. 20—SECTION OF KYNOCH'S SUCTION GAS PRODUCER

THE COMPLETION OF A CONTRACT.

THE question as to when a man who undertakes a contract for work and labour is entitled to sue for the contract price not infrequently arises in relation to engineering contracts. Suppose the contract provides that certain machines shall be supplied, erected, and put into good working order for a specified sum of money. The contractor supplies the machines and does the greater part of the work. Owing to lack of funds, or for some other reason, he does not fulfil his entire obligation. Can he recover payment for the work done? The law says "No. If the contract is entire the work must be fully performed. Otherwise he cannot recover anything." Cases may arise, however, in which the employer may be taken to have accepted that part of the work which has been performed, and he will then have to pay for it according to measure and value. In other words, to use a legal phrase, the contractor will be entitled to sue on a *quantum meruit*. But what constitutes "acceptance" of work for this purpose? If A. erects a machine on B.'s land, B. is bound to accept the result of A.'s labour; he cannot help himself. Hence the fact that an employer does not remove the work from his premises, or that he makes use of it, is not evidence of acceptance. But if he puts it out of the power of the plaintiff to complete the work, as by completing it himself or employing another contractor, then must he pay for what has been done? In a case which was recently heard in the Divisional Court, an engineering firm had contracted to move certain machinery into a laundry and to put it into "good working order." Having completed the job—as they contended—they sued for the price. The employer resisted on the ground that the work was badly done, but in one letter they wrote "we have had to call in another engineer to complete." The Court held that this was evidence of acceptance *pro tanto*, and allowed the plaintiffs to sue for the work done according to measure and value.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE LATE MR. F. W. WEBB AND COMPOUND LOCOMOTIVES.

SIR,—In the current issue of THE ENGINEER I note a letter from a correspondent signing himself "Lynx," *apropos* of my letter of June 8th, which you were good enough to publish, in which I endeavoured to do justice to the late Mr. F. W. Webb's professional career and his services to the London and North-Western Railway. I do not think your correspondent's letter is at all likely to affect the favourable judgment regarding these points which so many members of the engineering profession and of the public who are interested in railway matters hold in common with myself, and which my letter intended and ventured to express. But there are some rather remarkable misstatements in your correspondent's letter I should like, with your permission, to correct. Personally I have the greatest possible admiration for the London and North-Western Railway generally, and, as I have already sufficiently indicated, for its locomotive department particularly; and in appreciating the latter and its late chief, I must be understood to do so defensively, and not offensively, and only because I do not think sufficient justice has been done to either.

Your correspondent's statement as to the Webb compounds having to be "assisted to start their trains out of stations for a given distance" by an engine in the rear "as a regular practice," so far from being an indubitable fact, is an indubitable error. I have certainly known trains assisted out of a station by a light engine in the rear on occasions, but not as a regular practice or when the Webb compounds specially were on the trains, but only when the excessive weight of the train, the state of the weather, and perhaps the condition of the rails, or the fact of there being a heavy adverse gradient to face at the outset may have required it; and this asistance was rendered totally irrespective of the type or duplication of the engine drawing the train. The only places on the London and North-Western Railway where I have known such starting assistance given are Euston, Carlisle, and Shrewsbury, each of which stations lies at the foot of a very heavy gradient, aggravated in the latter case by a sharp curve out of the platform. The sharp rise out of Euston to Camden-road is well-known; and at the south end of Carlisle Station begins the heavy and continuous rise to Plumpton, near Penrith. For trains stopping at Penrith as a regular thing, and for non-stopping trains in adverse weather such as one so frequently meets with on the Preston-Carlisle road, a bank engine from Tebay to Shap Summit has been a recognised thing always, and simply a means of saving time—not a reflection on the train engine's capability of getting up. And there again one has a continuous climb of over seven miles, starting on a gradient of something like 1 in 150, and consisting chiefly of 1 in 70, and the down Shap climb actually commences 1½ miles south of Tebay Station at the water troughs.

As regards the Euston incline, also 1 in 70 and a mile long, I can very well remember when all the principal trains going out of Euston were given an energetic shove up to the canal bridge and engine sheds at Camden by a small light engine, which used to lie in wait at the north end of the down platform and rush after the train and butt up against the tail of it in a fussy and amusing fashion; and this was done as a regular practice, quite regardless of the class of engine or engines pulling the train. But one day the "banker" overdid things, and owing to the clouds of steam from its own cylinder cocks or a fog, concealing the train it was to assist, it ran violently into the rear coach and butted it off the rails. After this, which was, I think, in 1889, the Board of Trade stopped the performance. Your correspondent states that the Webb compounds were bad at getting away with a train and bad timekeepers. They were nothing of the sort. As a matter of fact, the compounds worked best when working their hardest, as all compounds do, and they were first-rate hill-climbers. Their working with heavy trains up the steep hills on the Preston-Carlisle road was entirely satisfactorily, and a revelation of locomotive power and efficiency; and they could be run down hill and generally pushed without any difficulty whatever.

Your correspondent further states that they were expensive failures. I say they were economical and efficient successes, though not equally so in all classes; and I say, further, that, granted the inevitable but not very much higher first cost and repair and maintenance costs, the actual mileage costs of all the Webb compounds were no higher than for the ordinary type of locomotives. It must be remembered that the compounds, both goods and passengers, were given the heaviest traffic of the line

to deal with—that is indisputable; and the compound mileage was, per engine, very considerably higher between repairs and per annum than that of any other class of engine on the line. Your correspondent states that "the small saving in fuel consumption of the Webb compounds was a negligible quantity." That, again, is entirely wrong; but it is something for him to admit that these engines did effect any saving.

And here also I am speaking from intimate, personal, and practical knowledge, and have before me the figures for twelve consecutive months' passenger and goods locomotive working of the entire London and North-Western Railway, taken by myself from the monthly official sheets as posted up in the engine sheds, *i.e.*, total engine and train mileage, total coal, oil, and tallow consumed, and total of each per engine and train mile, wages of drivers, firemen and cleaners, and total inclusive costs per engine and train mile. Also I have similar figures for coal consumption, cost per mile, total mileage, &c., for the other twenty-four principal railways of the United Kingdom, for twelve consecutive months, and it happens that the London and North-Western Railway coal consumption per engine and train mile is ·21b. above the average, and a long way below the maximum, while the cost per mile is appreciably below the average, and well below the maximum. And of the London and North-Western Railway engine and train mileage, that run by the Webb compounds represents a very considerable percentage. The most successful class of passenger compounds was the 7ft. or "Teutonic" class—the third in order of creation—and one of these engines did over 200,000 consecutive miles on a checked coal consumption of 32 lb. per mile, working the heaviest Scotch express traffic from Euston to Carlisle and back, *i.e.*, 600 miles, each day, for six days a week. This was, of course, an exceptional duty, and a special test, repairs and special cleaning being attended to every Sunday at Crewe. But it shows what these engines were capable of doing. In fact, the general indictment, which your correspondent brings against the Webb compounds cannot possibly be sustained, either by his bare assertion, or by the actual facts of experience, which are emphatically against him.

I do not say that they were faultless or incapable of improvement; I do claim that Mr. Webb was fully justified, both by preliminary experiment and by practical results, in developing the application of the principle and his system of compound locomotives on the London and North-Western Railway as extensively as he did, and that in doing so he effected a distinct economy in his department, and neither caused the London and North-Western Railway any loss nor did the shareholders any injustice.

As to his successors' locomotives, the new powerful four wheels coupled bogie engines, I have nothing to say against them. I have had no practical experience of them other than travelling behind them and watching them at their work, but I should say they were thoroughly good engines, of satisfactorily simple design, and quite as heavy and powerful as any locomotive in this country needs to be. The six wheels coupled bogie passenger engines, of the MacIntosh type, I consider a mistake, like the rest of their kind, as the multiplication of large coupled wheels in a fast-running and heavy-working engine is not conducive to efficiency or any sort of economy, and does not leave sufficient margin of brake horse-power for the work required to be done. Too much power is absorbed in the working of the engine itself.

I must apologise for the length of this letter, Sir, and hope I may be excused for trespassing so much on your courtesy. F. A. L.

SIR,—I must say I agree with your correspondent "Lynx" that it is a great pity any attempt should be made to justify the introduction of the three-cylinder compound engines on our premier railway.

Speaking as a frequent passenger on the line, it was a marvel to me how the traffic department got through the "compound era" without serious loss of prestige.

A very consistent policy of "double-heading" on all the principal expresses was rightly adopted, as I can vouch for the fact, by repeated and exasperating experiences, that even with moderately weighted and timed trains the compounds often lost time badly. And I well remember one most aggravating delay on the curve outside Wolverhampton, when a "Dreadnought," that had lost time steadily from Crewe and was stopped by signal, was quite unable to move until a tank engine could be procured to assist her in.

Very few, I think, will deny that Mr. Whale has done the right thing in relegating the whole of these most unsatisfactory machines to their proper place—the scrap-heap; and though certain critics sneer at his new engines, and call them "glorified steam winches," my very satisfactory experiences behind them on the heaviest and fastest London-Manchester work leads me to think that they might very properly be called "glorified Dunalastairs," and I don't think higher praise could be accorded to them. They are the best timekeepers in England. G. D. S.

Manchester, June 25th.

PATENT LAW.

SIR,—It must indeed be some consolation to find that Mr. Carpmael and I are agreed upon one point, namely, that our correspondence has lasted long enough, but I cannot permit his misleading statements to close with an equally misleading summary.

The three most essential points at issue are:—

(1) Is our law for compulsory licences adequate and satisfactory?

(2) Is the grant of compulsory licences preferable to compulsory working?

(3) Is it true that if this country introduces compulsory working it would be compelled to withdraw from the international union?

I have fully dealt in a separate letter, published in your issue of June 1st, with points one and two; permit me to add only a few words to point three.

It is quite true that the Chambers' resolution proposes that patents for inventions which are worked without, but not within, the United Kingdom should be revoked, subject to certain safeguards for the protection of the owner of the patent, whether British or foreign. It is also true that, in effect, this resolution, if adopted, would chiefly concern foreign holders of British patents, but it is not in any way invidiously directed against foreigners. It would in like way compel any holder of a British patent, whatever his nationality, to work it here if he worked it abroad. I need not reiterate the arguments; the justice of the Chambers' resolution is self-evident. So far from its being true that the Chambers' proposal would necessitate the withdrawal from the Union, I have shown in my letter published in THE ENGINEER of May 18th that the International Union has actually provided for the forfeiture of patents not worked within a certain time.

The resolution unanimously passed by the United Chambers of Commerce is much more lenient to the foreign or British owner of a patent than the provision of the International Union. By the Chambers' proposal a British patent cannot be forfeited within the whole legal term of a patent so long as it is not worked abroad. The working abroad is the test whether or not the owner of the patent has got over the initial difficulties of carrying out the invention. One effect of this correspondence, in which you have been good enough to allow the controversialists full scope, is that the whole ground has been thoroughly gone over. There is, however, one disadvantage to a weekly reader—an able dialectician, such as Mr. Carpmael, if left uncorrected, is capable of making "the worse appear the better reason." Necessary correction cannot appear until the next issue, whereas the bane and its antidote ought to be taken at the same time.

The Manchester Chamber of Commerce is therefore taking steps to publish *verbatim* proceedings before Mr. Lloyd-George—and will include, Sir, with your permission, this correspondence—in pamphlet form, and its secretary will be glad to send a copy to any person who has been sufficiently interested to follow the controversy. IVAN LEVINSTEIN.

Manchester, June 20th.

BOILER EXPLOSIONS IN SINKING SHIPS.

SIR,—In your issue of May 11th I noticed a letter on the prevailing fallacy that boilers under full head of steam explode when suddenly submerged in water, and the following may be of interest in support of your correspondent's contention. In 1883 an old paddle steamer called the Yat-sai was generally overhauled and renovated, and was fitted with two new cylindrical boilers to carry 40 lb. working pressure. I was invited as a guest for the trial trip of 39 miles out and back, but being very busy at the time preparing for a trial trip of my own, I did not form one of the party. About half way on the outward run one of the boilers burst, blowing away the whole side of the vessel and the superstructure, together with all the guests and officers who were at lunch.

As they sat at table each alternate one was killed. The survivors, who were said to have been thrown 100 yards, except for shock were uninjured, and heard no sound of the explosion.

It was abundantly proved that the explosion was in no way due to defects in the boiler, which had a high factor of safety in all parts, and it was understood at the time that the bursting pressure was fully 240 lb.

The boilers were set very close together, and the neighbouring boiler was absolutely uninjured, although it must have been immersed in a few seconds.

When H.M.S. Victoria went down in the Levant, the survivors reported that they heard the boilers explode. But she was under full speed at the time, and she turned turtle, so that when the water reached the fires the steam generated had no free exit, and would, therefore, but on a much larger scale, make much the same noises as are made by a boiler blowing off under water. I am sure no boiler explosion took place.

I was once in the engine-room of a steamer that was very rapidly sinking and while the stokeholds were flooding. She had passed over a rock at full speed, cutting great holes in her bottom, and the sixteen fires had been pushed to the utmost. There was no explosion, but the fuss made by the water coming in sudden contact with 280 square feet of incandescent fuel might have led an outsider to describe it erroneously as such.

Victoria, B.C., Canada, May 31st. JAMES K. REBBECK, Consulting Engineer.

THE COMMERCIAL ORGANISATION OF ENGINEERING FACTORIES.

SIR,—In Mr. Henry Spencer's interesting article on the above in your issue of June 22nd, the method of drawing material from the stores by foremen's requisition notes is not altogether satisfactory. The foreman in charge of a considerable number of men should spend his whole time in supervising their work, and in performing other duties which cannot be relegated to a subordinate. A much better plan of obtaining the necessary material is to issue the requisitions and job cards for both material and labour from the shop manager's office to the foreman showing the exact quantities required, the latter being obtained from the lists of parts; this method relieves the foreman of all clerical work, excepting in cases of spoiled material, which must obviously be replaced by a special note. In this connection the system in vogue in several works for dealing with wasters consists of charging them to one of three accounts, entitled "faulty design," "faulty material," and "bad workmanship," which are placed before the works manager at stated intervals. This plan has much to recommend it, as an excellent check is thereby had on the foremen, who are thus entirely debarred from drawing stores for works order numbers.

Another point in Mr. Spencer's paper is the method of manufacturing finished parts in batches without due regard to the number of cars on order. If the latter are only being made for customers in a small way this plan is unavoidable; but in large works, where all orders are or should be for stock, batches of finished parts should exactly suit the requirements of the shops for stock car orders, with slight additions to cover breakages in some cases.

If this rule be departed from in manufacturing motor cars, which are continually being improved in design, the undertaking will be saddled sooner or later with numbers of obsolete parts which must either be scrapped or worked into cars specially designed to use them in.

Ipswich, June 26th. W. O. HORSNAILL, A.M.I. Mech. E.

IRISH LIGHT RAILWAYS.

SIR,—I think the writer of the paragraph on Donegal 3ft. gauge railways in your last issue was not sufficiently acquainted with his subject. To deal first with insufficient maintenance, I am not concerned to defend the northern line farther than to say that what one man calls penuriousness another man calls wise economy, and it is often an open question which is which.

With regard, however, to the southern line, I really must point blank deny that there are dirty engines with leaky joints to be seen on it.

Moreover, there is really no excuse for and no existence of insufficient maintenance of the State lines even if the Board of Works would permit it, because the company did not expend the capital, and cannot, therefore, expect a return on it; and as far as the southern company is concerned, on the Donegal to Killybegs portion they are indemnified against loss by portions of the county, and on the Stranorlar to Glenties there has usually been a small profit on the working. Further, both the northern and the southern companies are dividend paying lines.

With a good deal of the latter part of your article I am in agreement, especially as to the cost of complying with the requirements of the Board of Trade. On the other hand, the idea of making a road, even through the mountain districts, without fences would be quite impracticable, and any attempt to make an unfenced line through the populous parts would have had to be carried out under police protection.

With regard to train mileage, it is much more difficult to reduce with profit than a stranger passing through the country would think; and though one goods train a day each way would do all the work, you would lose all your passenger traffic except long-distance fares, for people in this country will walk long distances to save two or three pence.

Probably one goods train a day and more frequent steam motor service for passenger, parcel, and mail traffic would be more to the point. THE CHAIRMAN OF THE DONEGAL RY. CO.

June 28th.

RAIL MOTOR SERVICES.

SIR,—I note with satisfaction, which not a few of your readers will share with me, that a rail motor service connects Belmont with West Croydon. Would it be asking too much of the London, Brighton, and South Coast Railway to inaugurate a like benefit to the public between Seaford and Lewes, with halts at Iford and Piddinghoe? These halts might be connected to the towns named after them by ferries, and these ferries ought to find employment for superannuated London, Brighton, and South Coast Railway Company's servants. A half-hourly service betwixt Seaford and Lewes would be as greatly appreciated as an hourly one between Hastings and Ashford would be if the South-Eastern Railway Company thought fit to benefit the public in that locality, where a rail motor service would be an unspeakable boon.

Folkestone, June 16th. HENRY JAMES.

P.S.—How much longer will it be before the *entente cordiale* is realised sufficiently to allow of the Franco-English submarine tunnel being made?

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, June 13th, 1906.

CROP reports just published to-day by the Government show the prospective wheat supply at 713,399,000 bushels. These figures have been exceeded only once, namely, in 1901, when the production was 748,460,000 bushels. Other cereal crops are similarly abundant. Advices from the south are also quite favourable as to cotton. Such conditions as these are naturally having a favourable influence upon general trade conditions.

The steel industry is still feeling the influence of a heavy demand all along the line. Announcement has been very recently made through the United States Steel Corporation of this city of the purchase by various interests of some 250,000 tons of Bessemer pig for use during the latter part of the year. Quite a number of rail contracts have also been reported from the same source, some of these contracts running into very large figures, and nearly all for next year's delivery. The reason for this activity and the accompanying demand for basic and Bessemer pig is due in large measure to a feeling of alarm among the larger producers of rails and shapes that the supply of raw material is likely to run short during the next six or eight months. In addition to this, there has been some difficulty in Bessemer furnaces obtaining a prompt supply of ore. A good many of the furnaces have been running so long without stoppage for repairs that they will soon be obliged to blow out, and this means a material decrease in the supply, and just at a time when the trade can ill afford to encounter a deficiency. The situation is critical in a measure on account of the almost unexpected presentation of extensive requirements for crude and finished material from sources of demand that were not anticipated. A great many enterprises are springing up, and the first intimation of the situation is inquiry from those promoters who desire material of various kinds furnished at dates between September and the following six or nine months. In this way the market is kept in an agitated condition, and prices, instead of showing any tendency downward, are destined to remain about where they are. There is an excellent demand for foundry irons for special purposes by hardware founders, agricultural and implement manufacturers, makers of special machinery and general jobbing houses.

The recent advices concerning copper from Montana are that the increase in production this year over last is about 20 per cent., and that the production of copper in all sections is at the rate of 90,000,000 lb. per month. Adding to this the imports, it brings the total available supply proper to about 108,000,000 lb. per month. The average export of copper, so far this year, has been 16,500,000 tons monthly, and the domestic consumption has been at the rate of 30,000 tons monthly. The total supply has exceeded the coal consumption since the first of the year by upwards of 25,000 tons. It is a question how long the accumulation of copper will continue in the face of such circumstances. Copper consumers have been looking for a decline for the reasons mentioned; but the buying up and holding of copper has thus far served to maintain prices, which at present are for August and September delivery 18½ cents for electrolitic.

NEW YORK, June 20th.

The entire steel market is in a very satisfactory condition, and a heavy demand is being developed day by day from all parts of the country. A great many new enterprises are coming to the surface, and the promoters of these enterprises are anxious to obtain material as rapidly as possible in order to prosecute work during the last half of the year. The pig iron output for the current year, it is now estimated, will reach close to 25,000,000 tons. The demand for May was unprecedented, and it is believed that this demand is partly due to the knowledge that quite a number of blast furnaces would blow out and remain out for several weeks. Quite a number have blown out within the past week, and a number will blow out within the next few days. During the past week the highest price for the year in pig iron was reached, and to-day's indications are that basic and Bessemer will go a little higher. The Cambrian Steel Company has contracted for 90,000 tons; the Republic Iron and Steel Company for 60,000 tons. The belief is that the larger concerns are stocking up for future emergencies. The steel billet market is very strong, and sales have been made for large lots at 27 dols. at Pittsburg and 28 dols. for open hearth. Large orders for corrugated iron roofing are coming from San Francisco. Plate iron has received a stimulus from the announcement that the American Shipbuilding Company has undertaken to construct ten large Lake vessels. Contracts have already been placed for two of them. The bar iron market is also active as well as the sheet iron department, and the mills are running full time and are unable to accumulate any material.

The Western implement interests are still buying freely of various kinds of steel, and the large engineering plants are also extending their engagements, and are purchasing special brands of iron for which they are glad to pay full prices. The fuel market is active, and the entire coke production is moving into consumptive channels as rapidly as cars can be loaded. The copper market is without special interest, excepting that there was a break in prices due to London advices. The total exports for the first seventeen days of June are 10,885 tons. A good deal of copper development is in progress throughout the Western mining section. It is certain that the domestic copper supply will be materially increased within the next few months. These sources of supply are under independent control. The lead market is quiet at 5·90, and spelter is selling at 6·15. The rumours are again renewed that certain large consumers of steel will place orders for supplies during the month of July, and there are some reasons for attaching importance to them. The producing interests are content with the situation as it is, as the mills are overloaded with orders, and the current requirements from small buyers will be sufficient to absorb their entire spare capacity.

THE work of extending the Freycinet Docks at Dunkirk, authorised by the law of December 24th, 1903, has been commenced. The work comprises the lengthening of the existing dock accommodation by about a mile of quays. This has necessitated the cutting of the fortifications on the western side of the town, which has been begun, and as the docks will occupy the site of maritime goods sidings of the Northern Railway it is intended to remove the fortifications to about 1½ miles distance, which will then leave space for further docks.

CONTRACTS.—We are informed that the North-Eastern Railway Company has placed an order for two 30-ton chain-testing machines with Messrs. W. and T. Avery, Limited, of the Soho Foundry, Birmingham. This firm has also secured an order from the Mersey Dock and Harbour Board for two 30-ton improved railway weigh-bridges, sufficiently strong to allow of a 60-ton locomotive passing over.—The Mirrlees Watson Company has recently secured a number of important contracts for independent condensing plant, including the following:—A surface condensing plant to work in connection with a 3000-kilowatt Willans turbine for City of Leeds electric lighting station; an elevated self-draining counter-current jet condensing plant, dealing with 80,000 lb. of steam per hour, for the Dalzell Steel Works, Motherwell—Messrs. David Colville and Sons, Limited.—The Leyton Council have accepted the tender of Messrs. Helliwell and Co., Limited, of Brighouse, Yorkshire, for the glazing required to their new car sheds, the glazing to be on their "Perfection" system. The same company has also in hand the glazing for the extensions to the power station. Messrs. William Simons and Co., of Renfrew, have received an order from the Crown Agents to construct a 1200-ton twin-screw sand pump hopper dredger, fitted with special appliances for dredging the bar at Lagos, West Coast of Africa.

PORT IMPROVEMENTS AT HARTLEPOOL.

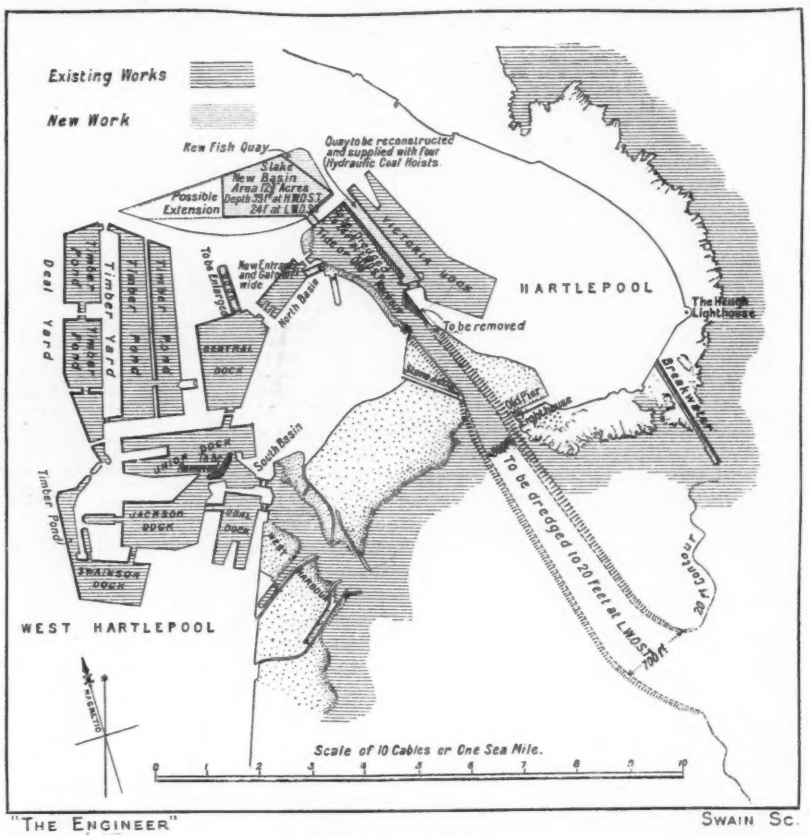
FOR many years the port of Hartlepool, well known for its imports of timber and iron ore, exports of coal, and the product of its shipbuilding yards, has held a high place among British seaports. The ever-increasing tonnage of modern ships, however, and the demand of traders and shipbuilders for greater facilities and accommodation, have caused the North-Eastern Railway Company and the Port and Harbour Commission—the two bodies which jointly control the port—to embark on an extensive policy of harbour improvement. The preliminaries for this work have already commenced.

The railway company is now engaged in dredging the old harbour, which will eventually be deepened to 24ft. at low water of spring tides. The old-fashioned coal spouts between the old harbour and the Victoria Dock have been removed, and the quay is being set back and reconstructed so that the largest vessels can lie alongside at all states of the tide, and can be quickly coaled by hydraulic coal hoists of the most modern description. An entrance, 80ft. wide, spanned by a swing bridge, is to be cut through the existing fish quay into the mud flat known as the Slake, which will be converted into a tidal basin of some 12¾ acres in extent, having a depth at low water of spring tides of 24ft. Accommodation will be found for fishing craft at a new fish quay of over 600ft. in length at the north-east corner of this basin, adjoining the main road and the railway. On the south side of the basin will be a quay of over 800ft. in length, where new ships of the largest dimensions can be fitted with engines, boilers, and machinery. A new entrance, 70ft. wide, with hydraulically operated gates and a depth of 30ft. on the sill, will be made into the North Basin, in order that the largest class of cargo vessels may be admitted to the docks. The company's existing graving dock of 570ft. in length will also be widened and generally improved.

The Port and Harbour Commissioners on their part, acting on the advice of their engineer, Mr. J. D. Howkins, have decided to deepen the entrance channel to the port from its present depth of about 13ft. at low water of spring tides to a minimum of 18ft. at the inner end and 20ft. at the outer. As the rise of spring tides is 15ft., the depth at high-water will thus be from 33ft. to 35ft. For this purpose they have added to their existing dredging plant by the purchase of a new dredger and steam hopper barge. The dredger named "Hartness," an illustration of which is given below, has just been completed at the yard of Messrs. Fleming and Ferguson, Limited, of Paisley, to the requirements of the Commissioners' engineer. She is of the barge-loading, self-propelling type, and is capable of a minimum output of 600 tons per hour at a depth of 40ft. Her dimensions are—length, 160ft. overall; beam, 30ft.; and moulded depth, 12ft. Steam at 120lb. pressure is supplied by two single-ended marine boilers of 9ft. 6in. diameter by 8ft. 6in. long to a compound inverted surface-condensing engine, having cylinders of 20in. and 40in. diameter by 24in. stroke. The buckets are of 16 cubic feet capacity, are specially designed to cut and deliver clay, and can be run at a speed of either 18 or 14 per minute. Two powerful steam winches are fitted at bow and stern for operating the mooring chains. The shoots are also worked by steam power, and the ladder is served by a powerful two-cylinder hoisting engine.

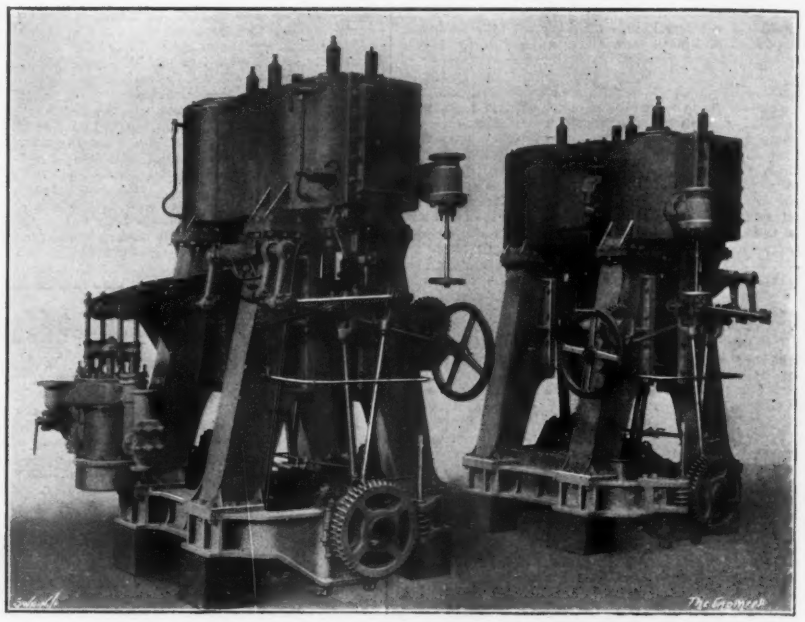
The steam hopper barge, built by Messrs. J. T. Eltringham and Co., and engined by Messrs. Hepple and Co., both of South Shields, is a twin-screw vessel of 127ft. by 29ft. by 12ft. Her hopper capacity, exclusive of coamings, is 500 tons, and her speed 9 knots. The hopper doors are lowered and raised by powerful steam winches, and a winch is also fitted forward for lifting chains and anchors and laying moorings. A view of this vessel is also given below, and an engraving of her engines above.

It is anticipated that with the dredging plant now available the required depth in the Commissioners' channel will be obtained in a couple of years. Dredging operations will then be directed to still further widening and improving the channel. A drawing of the port showing the old and new works is given herewith.



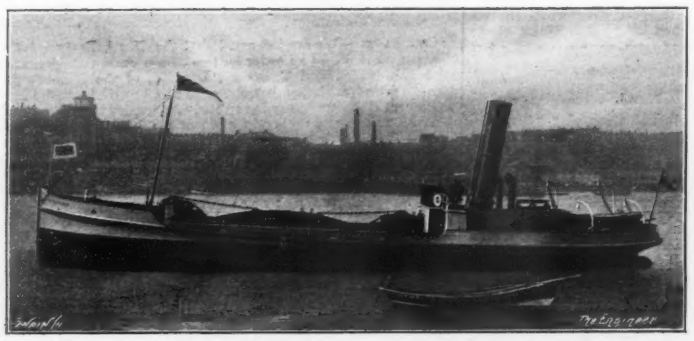
HARTLEPOOL DOCKS

ENGINES OF HOPPER BARGE FOR HARTLEPOOL

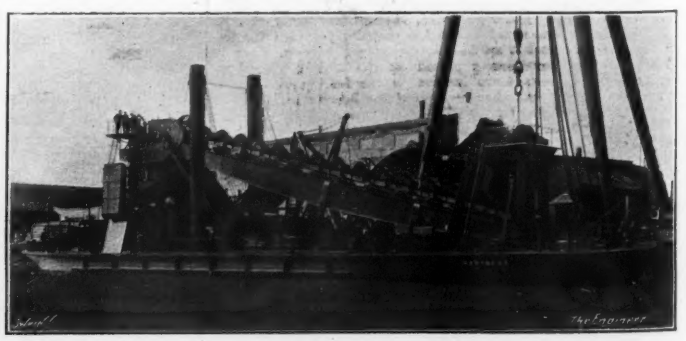


NEW FIFESHIRE RAILWAY.

A BILL for the construction of what is named the Newburgh and North of Fife Railway was obtained as long ago as 1897, but owing largely to the position of railways generally during the succeeding years, nothing was done till recently towards raising the money necessary for making the line. Now, however, contracts for the construction of the railway have been let, and the work will be proceeded with at once. The new railway will open up one of the most attractive parts of Fife to the public of Dundee, Perth, and intervening places on the south side of the river Tay. It commences by the junction with the North British main line at Glenburnie, and passes through the villages of Lindores and Kilmany. It then follows the line of the Motray Water and joins the North British main line to Aberdeen at St. Fort Station. At this end there is a loop line turning south towards Leuchars and St. Andrews. This loop is made so as to afford through communication from the West and North of Scotland to St. Andrews and the east of Fife district. In addition to the advantages which will be derived from the line by those resident in the district, its construction will provide a direct through route from Perth and places north and west of it with Dundee, Broughty Ferry, Monifieth, Carnoustie, Arbroath, and Montrose on the East Coast, as well as St. Andrews and the East Fife Coast, without the drawback which at present exists at Dundee through passengers having to go from the west to the east station. By its construction the last link in a continuous line of railway from the north of Aberdeenshire to Berwick along the East Coast will be supplied. This line, which is twelve miles long, is being constructed by a separate company, and is to be worked by the North British Railway Company under agreement.



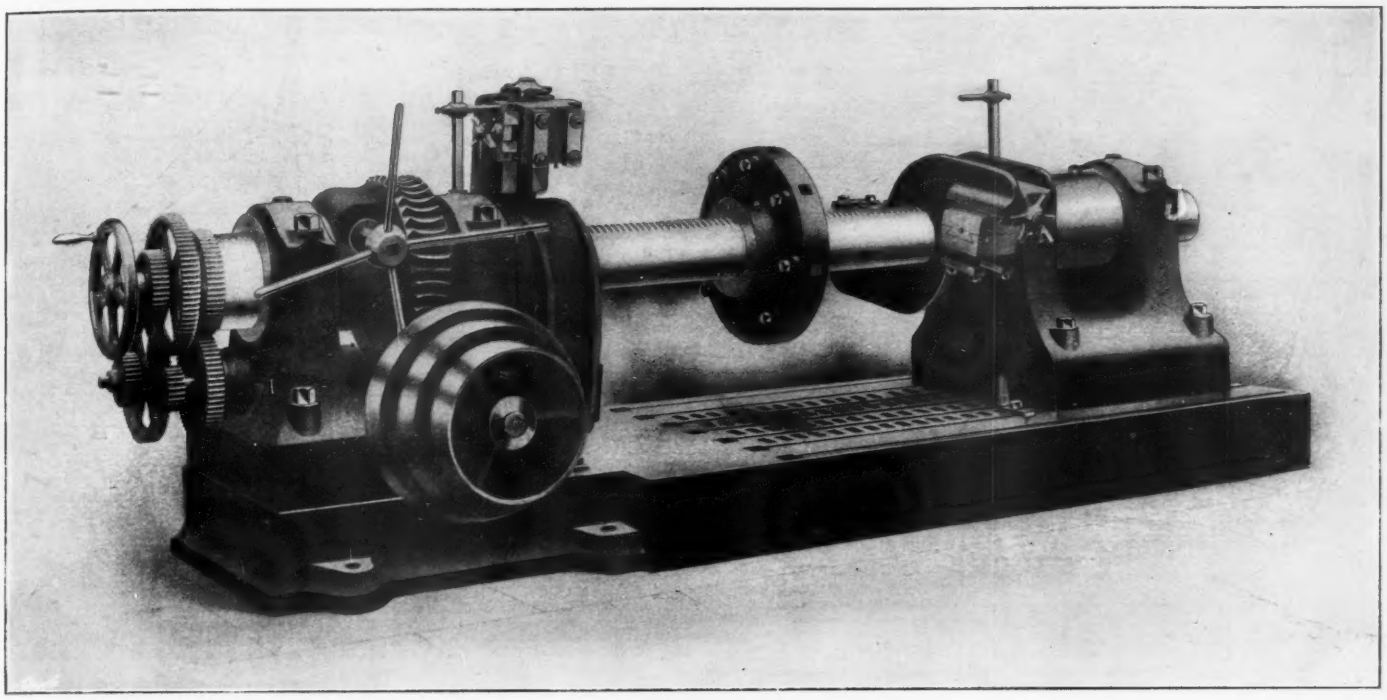
STEAM HOPPER BARGE



HARTLEPOOL DREDGER HARTNESS

BORING MACHINE

POLLOCK AND MACNAB, LIMITED, BREDBURY, ENGINEERS



HORIZONTAL BORING MACHINE.

A BORING machine designed and made by Pollock and Macnab, Limited, Bredbury, near Manchester, for machining cylinders, stern frames, &c., forms the subject of the illustration above. The driving head is actuated by a three-speed cone through worm gear on a sleeve, through which the boring bar travels, the sleeve being carried in two journals, with loose caps. The travelling head is mounted on the bar, and is moved along by a screw and nut, the screw extending the whole length of the bar. The head can be moved along by a hand wheel, or by power through feed wheels. Two facing heads, each having two tool-boxes, are provided. The facing tools are fed to and from the centre of the spindle by star wheels or by hand for setting in the usual way, and a hand setting up motion for adjusting the depth of cut without having to move the tools in the tool-boxes is provided. The boring head has square holes, in which cutting tools are held by set screws. The bar is of mild steel; the feed screw lies in a slot, which serves also to drive the boring head and the two facing heads. A rack is cut on the circumference of the boring bar for adjusting by hand by means of the pinion fixed to the main worm driving wheel. The bar is carried in a sleeve in the loose headstock. The base-plate is 10ft. long over all by 3ft. 6in. wide by 9in. deep, with T-slots and barring holes—the slots being planed out and under-cut for easy adjustment of the holding-down bolts. The maximum distance between the two facing heads is 3ft. 6in.; the diameter of boring bar, 7in.; its length over all, 10ft.; the largest cone is 20in. diameter by 4in. broad. This machine, which is one of several sizes, will bore 3ft. 6in. long; the feeds vary between 4 and 35 per inch, and the maximum gear ratio is 45 to 1.

AMERICAN ENGINEERING NEWS.

Bascule bridges.—In bascule bridges of the trunnion type, revolving on fixed bearings, a deep tail pit extending below the water line is almost invariably required to receive the counterweight arm, and this not only adds considerably to the cost of foundation and masonry work, but is difficult to make water-tight, and is more or less of a nuisance. In the Strauss design of bascule bridge, which has been adopted in several cases in the United States, the tail pit does not extend to the water line. This is effected by making the counterweight separate from the tail ends of the trusses, and supporting it from the trusses by a system of hinged links, so that the movement is in practically a parabolic curve, and the counterweight box remains all the time in a horizontal position. It may be built with the counterweight beneath or above the bridge. In the former case the tail ends of the trusses are carried under the floor of the fixed approach, and between them is hung the rectangular counterweight box, which is usually shallow, but wide and long. In the latter case the box is deep and narrow, and often placed excentrically in relation to the supporting tail pins. When the bridge is lowered the counterweight is above the headway clearance line; when the bridge is open the counterweight is within a short distance of the pavement of the approach. This latter arrangement has been adopted in the new Knippel bridge at Copenhagen, Denmark, where the counterweight will move between the towers of ornamental entrance gateways or portals.

A large rock-crushing plant.—A large stone-crushing plant, with a capacity of 7000 tons of product per day of ten hours, and operated entirely by electricity, has recently been built at Little Falls. The larger stone will be used for roads, railway ballast, concrete, &c., and the dust and fine screenings will be used in making cement bricks and concrete blocks at a plant operated by the stone company. The crusher is of the McCully vertical gyratory type, the gyrating shaft weighing about 9 tons, and the weight of the entire machine being about 110 tons; its height is 25ft. It has three feed openings 2ft. wide and 5½ft. long, so that it will take in stones of practically any size that may be fed to it, and it will be fed direct by small trucks from the quarry. The stone is delivered from the main crusher mainly as 5in. cubes, and falls upon a belt conveyor 32in. wide and 25ft. long, which delivers it to an inclined bucket conveyor or lift 60ft. long, from which it is discharged into two revolving perforated screens. These screens are 5ft. diameter and 15ft. long, supported by bearing rollers at the receiving end and at the middle. The discharge end is free. The rejections from these screens pass to four smaller crushers, the product from which is delivered into the conveyor, which again discharges it into the screens. The stone passing through the perforations of these screens falls upon a belt conveyor, and is delivered to two 35ft. sizing screens, from which it is delivered to the storage bins, which are 117ft. by 34ft. and 30ft. deep, with a capacity for 4500 cubic yards. These bins are built of reinforced concrete. The crusher is driven at a speed of 350 revolutions at the main shaft, giving 135 revolutions of the gyrating shaft; for the full capacity of 700 tons per hour it requires about 175 horse-power.

Geared locomotives.—The Chesapeake and Ohio Railway, is using six geared locomotives of the Shay type for steep-grade branches to mines. A three-cylinder vertical engine at one side of the fire-box drives a crank shaft connected by flexible sleeve couplings with shafts or bogies under the boiler and coal bunker, and on two bogies under the tender. These shafts have bevel pinions gearing with bevel wheels bolted to the faces of the bogie wheels. The total tractive effort is 53,000 lb., and the principal dimensions are as follows:—

Cylinders, three	17in. by 18in.
Cylinder volume	7·09 cu. ft.
Wheels, engine and tender	3ft. 10in.
Wheel base of each bogie	5ft. 4in.
Wheel base of engine	34ft. 4in.
Wheel base of engine and tender	58ft. 4in.
Length over all	70ft. 6in.
Boiler diameter	5ft. 2in.
Steam pressure	200 lb.
Fire-box	9ft. 6in. by 5ft. 1¼in.
Fire-box, depth at front	6ft. 10¼in.
Fire-box, depth at back	6ft. 6¾in.
Tubes: number, 316; length	13ft. 6in.
Heating surface, fire-box	180 sq. ft.
Heating surface, tubes	2220 sq. ft.
Heating surface, total	2400 sq. ft.
Grate surface	48½ sq. ft.
Coal in engine bunker	9 tons
Water in tender tank	8000 gallons
Weight on front bogie of engine	47½ tons
Weight on rear bogie of engine	46 tons
Weight on front bogie of tender	36 tons
Weight on rear bogie of tender	35 tons
Weight of engine	93½ tons
Weight of tender	71 tons
Weight of engine and tender	164½ tons

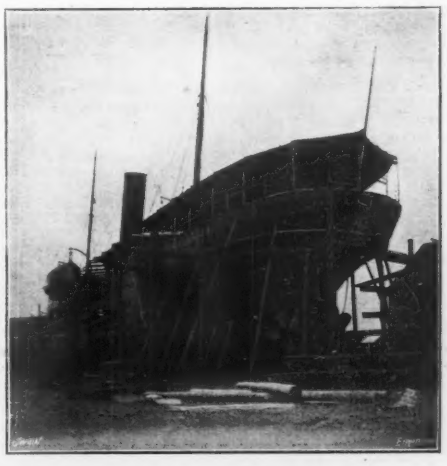
Electric rack-rail haulage in mines.—The Donohoe coal mines have a rack-rail and cog-wheel system of underground haulage, operated by electric locomotives. The haulage ways are lighted by electricity, and the pumping is done by electrically-driven triplex and centrifugal pumps. There are five main entries, the middle entry being the main air course, with haulage-way and air-way on each side. The entries follow the line of dip, and from them on each side at 500ft. intervals are face entries driven on the level. This arrangement gives a large tonnage of output per horse used in gathering, while all uphill hauling is done by the electric locomotives. The main haulage-way is 3000ft. long, with gradients of 1 in 42 to 1 in 25, although originally there were gradients as steep as 1 in 13. The five entries have a total length of about 10,000ft. The locomotives run into side entries to partings at which loaded trips are gathered by horses. As these increase and cause inconveniently large hauls for the horses the rack-rail permanent way is extended, using worn out material from the main haulage lines, these side entries being level. At each entry is a coloured electric lamp, which is lighted by a switch when a trip in the entry is ready for the locomotive. The voltage used is 250, and there are two four-axle locomotives of 160 horse-power. The rack is between the rails, and is a slotted plate with its sides sandwiched between two timbers, leaving only an opening wide enough for the collecting cog-wheel on the locomotive, the rack-rail being the conductor. In one test thirty-five trips were hauled from seven entries, with a total of 828 wagons or 93 tons per trip. The total distance travelled by the engine was 40 miles, and the total load was about 3100 tons, of which the coal itself represented about 1900 tons.

STEAMER FOR LAKE VICTORIA NYANZA.

THERE has recently been shipped to Mombassa from the yard of Bow, McLachlan and Co., Limited, Paisley, a new steel twin-screw steamer named the Clement Hill, which is

BOW OF THE CLEMENT HILL

intended for service on Lake Victoria Nyanza. This vessel, drawings of which are given on the next page, has been constructed to the order of the Crown Agents for the Colonies from designs by Messrs. Rendel and Robertson. Her principal dimensions are—length over all, 232ft.; length between perpendiculars, 220ft.; breadth moulded, 32ft. 3in.; depth moulded, 10ft. The propelling machinery fitted is of the

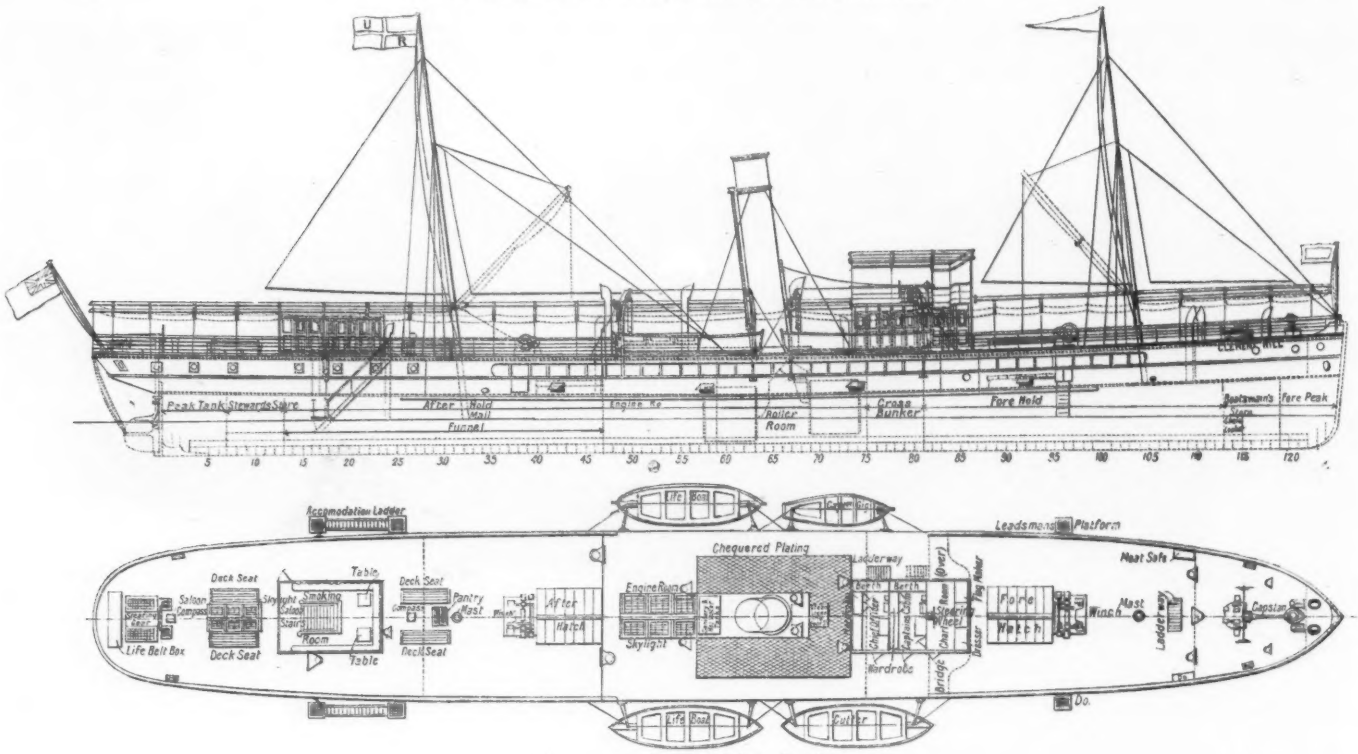


STERN OF THE CLEMENT HILL

twin-screw triple-expansion surface-condensing type, which is supplied with steam by three horizontal return-tube boilers. The vessel is fully equipped with up-to-date appliances for the expeditious handling of cargo, and is also provided with

TWIN-SCREW STEAMER FOR LAKE VICTORIA NYANZA

BOW, McLACHLAN AND CO., LIMITED, PAISLEY, BUILDERS



accommodation for first and second-class passengers, and for natives. The first-class accommodation is of a complete nature in anticipation of increased passenger traffic on the lake when the new Cape to Cairo Railway is completed.

Electric light is fitted throughout the steamer, the engines and dynamo, &c., being of the builders' own make, and the saloons and cabins are equipped with an installation of electrically-driven fans for ventilating purposes. The engravings on the previous page show the vessel erected complete in the yard of the builders, where she was put through a successful steam trial. After being suitably marked for re-erection at the lake side the vessel was taken to pieces, packed and shipped on board an export steamer to Port Kilindini, and from there she will be conveyed to the lake side over the Uganda Railway. This is the third steamer by the same builders for service on the lake, the two former being named the Winifred and the Sybil.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Raw Iron Trade.

In pig iron the only relief to the surrounding weakness is seen in respect of Lincolnshire qualities. Foundry and forge sorts of this material have been this week officially advanced 1s. 6d. per ton, and basic iron 2s. per ton. The minimum official price, free on rail, is now as follows:—Foundry iron, 62s. 6d.; forge iron, 50s.; and basic iron, 53s. per ton.

Black and Galvanised Sheets.

The galvanisers are decidedly busier than a while ago, and the effect is witnessed in activity at the black sheet iron mills. Ironmasters in this branch are much better occupied, and a hopeful view is taken of the future. Quotations are firmer, and £7 17s. 6d. to £8 is now obtainable for sheets of 24 w.g., while material of 20 w.g. is £7 15s. to £7 17s. 6d., and of 27 and 28 w.g. £8 10s. to £8 12s. 6d. The Galvanised Iron Association report that there are plenty of orders, and prices are strong; £12 10s. to £12 12s. 6d. is being got for galvanised corrugated "doubles."

Revival Needed in Bar Iron.

Revival is greatly needed in the unmarked bar trade. Demand from various causes has dropped off very much in this branch, and the competition for orders has brought prices down to a very low level. Improvement is promised after the quarterly meeting, which is fixed for July 12th, but it is at present difficult to see where it is to come from. Quotations are £6 5s. to £6 10s. per ton. There is a steady trade in marked Staffordshire bars, on the £9 basis for chain and anchor making, Admiralty work, and other purposes. Second grade best bars are £8. North Staffordshire bars keep at £7 5s., with a steady trade. Hoop iron of South Staffordshire make is £7 15s., and gas tube strip £6 12s. 6d. to £6 15s. per ton.

Steel Trade Good.

Steel occupies a sound position, and buyers have to be very pressing to obtain supplies, so busy are producers. The buyers have little to complain about, however, on the score of price. Steel makers, probably warned by previous experience anent foreign competition, are not taking undue advantage of the present buoyancy of demand to advance prices of rolled material. In this they are wise. The rise in finished steel has been very small. Mild steel bars are quoted £7 10s. to £7 15s.; engineering angles, £6 15s. to £7; and girder plates, £7 10s. to £7 15s.

Steel Rails.

Steel masters are watching with mixed feelings the information concerning the continued development of Canada's steel rail works for the supply of her own needs. Cable advices this week from America state that, owing to the pressure at American rail mills, heavy contracts for rails have just gone to Canada, where the works in Nova Scotia and Ontario are developing into big producers. The important contracts for steel rails required in the construction of the Grand Trunk Pacific Railway, which have just been divided by the Canadian Government between the Dominion Iron and Steel Company, Sidney, Cape Breton, and the Iron Company at Sault St. Marie, mark the transition in Canada from dependence upon British, American, or Continental manufactures to complete native producing. Already Canada is manufacturing rails at the rate of 350,000 tons per annum. This large quantity for so young a country may be increased indefinately, it is stated. An engineering expert, who has just returned from travelling in the Dominion states this week, locally, that British railmakers need not much longer anticipate any considerable market in Canada. If English makers desire to participate in the passing "boom," this authority pronounces that their only course is to imitate American enterprise, and establish branch steel works in Canada itself.

Engineering.

The engineering trades in Birmingham and district continue under considerable pressure for the execution of orders, as they have been since the year commenced. The railway wagon-building shops are being worked to their fullest capacity, night shifts having been requisitioned at some concerns. Good orders for wagons are forthcoming both from this country and abroad. The bridge-building yards are in regular employment. It has to be remembered in this connection, too, that improvements in their equipment and economy have materially enlarged their output during recent years. The different departments of the machinery trades are mostly busy. Many of the leading machinists are running plant overtime to keep pace with the demand. Makers of suction gas plants are in steady occupation.

Tin.

Birmingham manufacturers who have been inconvenienced by the advances in the metal market are very curious concerning a question which is to be asked of the President of the Board of Trade in Parliament next week by Mr. William Field. The President is to be asked "if he is aware that owing to American gambling in warrants in tin in London a corner was lately formed, and the price artificially raised to £203 per ton." Loss to British manufacturers in Birmingham, the Midlands, and South Wales is alleged. Further, the President is to be asked "whether he is aware that owing to the action of a bear clique in London, the corner has now collapsed, and that the price has already declined in a state of panic some £30 per ton, or to £174, thereby again jeopardising the whole trade?" The reply of Mr. Lloyd-George will be awaited with interest. Mr. Field wants the Government to prevent a recurrence of the gambling, but it is a foregone conclusion that they can do nothing.

Profit Sharing.

A profit-sharing scheme is in operation at Stafford in the gas and electric lighting departments of the Corporation, and the clerks and workmen of the gas department have just received a bonus for the past year representing 7½ per cent. on their wages, and the same classes of labour in the electric lighting department have received a 6½ per cent. bonus.

NOTES FROM LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, June 28th.

The Engineering Outlook.

FROM a conversation with the leading member of a large engineering firm in the Manchester district, we gathered that there is great briskness in most departments of this important industry. There is, however, an undercurrent of discontent amongst the men with the present conditions of labour, and in common with artisans in other trades, they are agitating for an advance of wages, and even a rescission of former agreements for the regulation of disputes and other points at present dealt with by arbitration. No doubt there is much to be said on both sides—by the men, that the present busy state of trade warrants a substantial advance in wages; on the part of the employers, that competition is exceedingly keen, and that orders are obtainable only by exercise of the utmost economy in production, &c. A conference will be held, when the points involved will be fully discussed, and it is to be hoped, in the interests of all concerned, that an amicable and mutually advantageous understanding may be arrived at.

The Pig Iron Position.

While there has been little or no change to record on the week, the position of pig iron remains very uncertain. There are many who think that the present lull is only of a temporary character, while others of the "bear" order are very pessimistic. Having made searching inquiries, we should be inclined to say that, having in view the continuance of heavy shipments and the small quantity going into stock, matters should improve rather than otherwise. Amongst consumers here there is no disposition to speculate, and practically they only cover immediate wants. The fact of the premium which has been asked for Lincolnshire foundry and forge iron was confirmed at the Saturday's meeting, coupled with a certain stiffness amongst English makers, points to a better state of things. On the other hand, Scotch pig, as also hematite, has given way by about 6d. per ton, and in second hands iron is being offered at under makers' rates. June, of course, is always a bad month, and this should be taken into consideration in estimating the various factors which go to make up the position.

Finished Iron.

Merchants report a very level trade passing. Bar makers in the district adhere to their quotations, and are well booked forward.

Steel and Semi Products.

Billets remain very steady, and there is a fair demand for plates.

Manufactured Copper.

Last week's reduction in sheets does not seem to have given any stimulus to the demand, and there is also very limited inquiry for both copper and brass tubes. The way in which raw copper was rushed up has been followed by a reaction, and buyers are holding off in anticipation of lower prices.

Sheet Lead.

Steady and unchanged.

Quotations.

Pig iron: Lancashire No. 3 foundry, 61s.; Lincolnshire, 56s. to 56s. 6d.; Derbyshire, 57s. 6d.; Staffordshire, 55s.; Middlesbrough, open brands, 59s. 4d. to 59s. 8d. Scotch: Gartsherrie, 63s. 6d. to 63s. 9d.; Glengarnock, 61s. 6d. to 61s. 9d.; Eglinton, 61s.; Dalmellington, 60s. 6d., delivered Manchester. West Coast hematite, 65s. 3d., f.o.t.; East Coast ditto, 66s. 6d. f.o.t. Scotch, delivered Heysham: Gartsherrie,

62s. 6d. to 62s. 9d.; Glengarnock, 59s. 6d. to 59s. 9d.; Eglinton, 59s.; Dalmellington, 58s. 6d. Delivered Preston: Gartsherrie, 62s. 6d. to 62s. 9d.; Glengarnock, 60s. 6d. to 60s. 9d.; Eglinton, 60s.; Dalmellington, 59s. 6d. Finished iron: Bars, £7 5s.; hoops, £7 17s. 6d.; sheets, £8 7s. 6d. to £8 12s. 6d. Steel: Bars, £7 5s.; hoops, £7 15s.; boiler plates (official), £8 12s. 6d.; plates for tank, girder, and bridge work, £7 7s. 6d. to £7 12s. 6d.; English billets, £5 7s. 6d. to £5 15s.; sheets, £8 17s. 6d. Copper: Sheets, £96 per ton; seamless copper tubes, 11¾d.; brazed ditto, 11¼d.; seamless brass tubes, 9½d.; condenser, 10½d.; brazed brass tubes, 10½d. to 10¾d.; rolled brass, 8¾d. to 9d.; brass wire, 8¾d. to 9d. per lb. Sheet lead, £19 15s. per ton.

Lancashire Coal Trade.

Short time is becoming general owing to the limited demand for house and shipping coal, and this causes a scarcity of slack and engine fuel generally. Meantime, prices tend in buyers' favour, although colliery owners, in most cases, adhere to official rates. Ordinary quotations are: Best coal, for domestic purposes, 13s. to 14s.; seconds, 12s. to 12s. 6d.; common, 9s. to 10s.; best engine fuel, 8s. 2d. to 8s. 11d.; steam and forge coal, best, 8s. 8d. to 9s. 3d.; best slack, 7s. to 7s. 6d.; medium, 6s. 5d. to 7s. 2d.; common, 5s. 5d. to 6s. 2d., at the pit; screened coal, 10s. to 10s. 3d.; unscreened, 9s. 6d. to 9s. 9d., delivered Manchester Ship Canal.

BARROW-IN-FURNESS, June 28th.

Hematites.

The hematite market remains remarkably active, seeing that general indications foreshadow a reduction of business, by the falling off in the demand from the chief sources of consumption—steel rails and steel plates. Makers are, however, very busy, and are well sold forward. They are producing as much iron as is possible with the plant they have available, and it is all going into consumption. Further than this, 1126 tons have been cleared out of warrant stock this week, and there is now on hand 74,145 tons. Makers hold comparatively small stocks. There are 38 furnaces in blast, and it is intended to put one or two charcoal furnaces in blast at an early date, but it is thought probable first of all that one or two of the furnaces now producing hematite iron will either be blown out or damped down at an early date, and, secondly, that prices will be easier before long. This prospect is doubtless keeping back some prospective business, and it is quite probable when lower values are reached a better demand will spring up from the users of iron in the steel trade who stand the chance of getting new orders if they can submit lower prices for rails and plates. Some good sales of ferro-manganese and spiegeleisen are reported, and in a short time the Workington Iron Company will enter the market with spelter produced from the dust which accumulates in the flues connected with furnaces engaged in the production of spiegeleisen. The demand for forge and foundry iron is quiet, but there are still large sales of scrap iron and other metals, some of which are produced from the breaking up of old warships at Morecambe and elsewhere. Iron ore is in good demand, and business is being done on a comparatively large scale forward, as the native supply is inadequate for the furnaces in the district, and large supplementary supplies are therefore obtained from foreign sources. Prices are steady at late rates.

Steel.

The outlook in the steel trade is not satisfactory. Although full time is being worked at the rail mills, the orders in the market are not numerous, and probably it will soon be necessary to curtail the output. Prices are steady at £6 7s. 6d. per ton for heavy sections not f.o.b. Shipbuilding material is in quiet demand. Plates are quoted at £7 7s. 6d. net cash. There are still some prospects of local orders for shipbuilding material. Merchant steel is very quiet. Steel foundries are only about half employed. The British Griffin Chilled Iron Casting Company is busy on wheels and other classes of castings.

Shipbuilding and Engineering.

Owing to the scarcity of orders in shipbuilding there is some talk of putting down two large cargo steamers for a possible purchaser. The Chilian Government are wanting two new battleships, and builders have sent in designs and tenders. Very little is being done in marine engineering, but orders for gun mountings, gun-carriages, and projectiles are plentiful.

Shipping and Coal.

Shipping is more briskly employed on iron and steel exports, which last week amounted to 24,137 tons from West Coast ports, an increase of 9663 tons on the corresponding week of last year. The aggregate shipments this year have reached 377,038 tons, being a decrease of 31,791 tons on the corresponding period of last year. Coal and coke are brisk, and prices are well maintained.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Trade Outlook.

IN the matter of business transactions the present week is regarded locally as one of the quietest of the year. Manufacturers are thinking of their half-yearly stocktaking, and are not desirous of entering into fresh commitments for raw material; while trade customers prefer to wait for the turn of the month before placing orders, however small. It says much for the soundness of the iron and steel trades in Sheffield when manufacturers are willing to accept deliveries of pig iron on current account, and this is reported to have been done in two or three cases, though, of course, most firms, if they can manage at all, are waiting for next week. The most satisfactory feature is the entire absence of grumbling, for usually when responsible officials of the large firms are asked as to the position of affairs, they have been inclined to adopt a very pessimistic attitude, and admit that while things might be worse, further depression was hardly possible. We hear none of that now. "We haven't any large new orders worth talking about," said a director of a world-famed concern, "but we have no cause for complaint. We have plenty of orders booked, and new ones, though small, are of sufficient volume to keep us well employed." This is the general experience, and there is no reason to doubt its continuance.

The Demand for Steam Coal.

The pressing demand for steam coal for shipment remains one of the chief features of the trade in the Yorkshire coalfield. All the hard coal pits are working full time, and a remarkably heavy tonnage is going by both rail and water to the shipping ports. The exports from the Humber last week were roughly 12,000 in excess of the corresponding week in the previous year, but single weeks are by no means a guide, and this figure is certainly much below the average. A good indication of the prosperity of the South Yorkshire coal trade is furnished by the traffic returns of the Hull and Barnsley Railway, and those for the twenty-five weeks of this half-year to date show the substantial improvement of £32,203, an appreciation of about 15 per cent. There seems at the present moment no likelihood of any break in this activity. Though the collieries are going, for the most part, the full six days a week, there are no signs of increasing stocks, notwithstanding that production now-a-days has enormously increased. The output of coal throughout South Yorkshire is heavier every year, and rapid progress is now being made with several new pits, so that trade activity is an absolute essential.

The Repeal of the Coal Tax.

A stimulating effect to business here, as well as in other colliery districts, has certainly been given by the repeal of the coal tax, and inquiries from quarters which have for long neglected Yorkshire are coming in quite briskly. The stipulation, of course, is for shipment after November 1st, and we understand that the Mediterranean ports are likely to be large buyers.

House Coal Prices.

It is stated that the colliery owners in the immediate neighbourhood of Sheffield have decided not to follow the lead of their competitors in West Yorkshire and in Derbyshire in the matter of house coal prices for the summer months. In the Wakefield, Normanton and Barnsley districts, as well as round about Chesterfield, owners have all agreed to the usual 1s. per ton summer reduction, the lower figure applying until the 1st of September. In the Sheffield district this is not to be done, not because there is any particular briskness in the house coal trade, but presumably because an effort is to be made at the beginning of September to hoist quotations above the level of those of last year. In the meantime no doubt the various collieries will make bargains where they can, perhaps with ruinous underselling, but giving the buyers to understand that the concession is—a concession and nothing more.

Coke and Nuts.

Prices for coke show a rather firmer tendency, and the outlook in this department is particularly gratifying. Best washed foundry samples have no difficulty in bringing 12s. 3d. to 12s. 6d. per ton at the ovens, while there is a strong inquiry for gas coal at firm rates. Nuts and small manufacturing fuel continues in strong request, with no falling away in quotations.

An Advance in Pig Iron.

The firms comprising the Lincolnshire Ironmasters' Association have at last made the expected move in an upward direction, for at their meeting last week-end they decided to advance the minimum quotations of forge and foundry iron 1s. 6d. per ton, and of basic iron 2s. per ton. This movement only brings the official quotation into line with the basis of recent transactions, for business for the last month has only been possible at rates averaging 2s. per ton over the minimum figures, but it is important as indicating renewed confidence in the future. There are many who regard this step as but the first towards a general revival similar to that which put the trade on its feet a year ago, and certainly the general position of trade warrants this optimism. Quotations for raw material delivered in Sheffield are now as follows:—Lincolnshire forge, 53s. 6d.; ditto foundry, 56s.; ditto basic, 54s. 6d.; Derbyshire forge, 52s. 6d.; foundry, 56s.; East Coast hematites, 72s. to 72s. 6d.; West Coast ditto, 73s.

Railway Material.

The manufacture of railway rolling stock material continues to be one of the staples of the large firms, and it is gratifying to hear that not only are they fully employed now and with work booked to cover them for the next few months, but that substantial inquiries for new contracts are being constantly made. One of the Argentine railway companies has sent out invitations for tenders for a heavy quantity of carriage and wagon axles, and the Bombay and Baroda Company is in the market for a large supply of general railway material.

Staveley Coal and Iron Company.

There is much speculation just now as to the proposals of the directors of the Staveley Coal and Iron Company. In February last the shareholders received a circular stating that it was proposed largely to extend the business by the construction of new blast furnaces and new coke ovens, while the company was joining with the Hickleton Main Company in the sinking of new pits at Brodsworth, near Doncaster. It was intimated then that new capital would be required, and that advantage would be taken of the opportunity so to deal with the present shares as to make them less unwieldy. We now understand that it is proposed to give £1 shares to the full value in exchange for the present £60 paid shares, while the new capital will not be raised by any call on the liability of the present shares—the "A" shares, for instance, though £60 paid, are of the nominal value of £100—but new £1 shares will be issued, and they will be offered to present shareholders on terms which will represent a very considerable bonus.

Large Order for Projectiles.

Advices have been received from Rome that Messrs. Thomas Firth and Sons, Limited, of Norfolk Works, Sheffield, have been awarded the contract for the supply of heavy projectiles to the Italian navy, the value of the order being said to approach £200,000. Up to the time of writing, the firm is without further details, but does not doubt the correctness of the report.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Situation in Warrants.

VERY little business has been done of late in Cleveland pig iron warrants, and the fluctuations in them have been within rather narrow limits, the highest price this month being 51s. 0½d. cash buyers on 11th, and the lowest 49s. 9d. on Tuesday of this week, but mostly the quotation has been about 50s. It is a long time since holders of warrants have shown such an disinclination to operate, and the lack of transactions is due more to that than to the backwardness of buyers. It may be inferred from this that the holders do not think that this is the most favourable time to sell, and that if they continue to keep the iron for some time longer they will be able to realise better prices. This is not likely next month, but almost invariably in the latter half of August and in September prices improve with the brisker autumn trade. It is pretty clear also that though there is a stock of over 640,000 tons of Cleveland pig iron in Connal's public stores, it is held in comparatively few hands, otherwise there would be a good deal more selling. It is believed that if a price close to 50s. can be got for Cleveland warrants in what is usually such a quiet month as June, August will bring a still better figure. Cleveland warrants are evidently in strong hands, and with cheap money the cost of carrying will not be heavy. The outlook for the autumn is good.

Cleveland Pig Iron.

Makers' iron continues dearer than Cleveland warrants, and, moreover, is not so readily obtainable for early delivery, as few of the makers have any in stock, and what they will produce for some weeks to come is in most cases already sold. No. 3 Cleveland G.M.B. pig iron has been sold this week as low as 50s. 3d. per ton for early f.o.b. delivery, but 50s. 6d. has been the regular figure at which business has been done. Germany during the past half-year has taken a large quantity of Cleveland foundry iron, but it is to be doubted whether anything like the same quantity will be wanted in the second half, as the German ironmasters are doing their best to increase the production and do away with the shortage in the output there. The price of No. 1 Cleveland pig iron is 52s.; No. 4 foundry, 49s. 9d.; No. 4 forge, 49s.; mottled, 48s. 6d.; and white 48s. per ton, all for early delivery. The lower qualities of Cleveland pig iron have of late been more largely produced, and the prices are, therefore, relatively cheaper than that of No. 3.

Hematite Iron and Ore.

Buying continues slow, as far as regards East Coast hematite pig iron, but all that is being produced is going direct into consumption, and makers have practically no stock, neither is there any in the public warrant stores. Still the prospects of the shipbuilding industry, and through that of the plate and angle trades, are not favourable to any increase in the demand for hematite pig iron, and people are not much disposed to buy for delivery ahead. Makers, however, will not further reduce their quotations, and this week the regular figure for mixed numbers has been 65s. 9d. per ton for early delivery, with 63s. 6d. for No. 4. Merchants likewise adhere to that rate, but there is not much in second hands. The price of Rubio ore has been reduced to 19s. 6d. per ton, c.i.f. Tees, but it is still too high.

Pig Iron Stocks.

Makers have very little in their yards, and the stock in the public stores is quickly declining. An increase was reported one day since last report of 2343 tons, but that was due to the fact that the shipping facilities were not adequate, and the vessel chartered had to get her cargo at some of the makers' wharves. Up to 27th Connal's stock of Cleveland iron in June had decreased 27,850 tons, making 108,048 tons since the stock began to decline in March, the quantity having dropped to 642,047 tons.

Shipments of Pig Iron.

These bear testimony to the great activity of the pig iron trade; and deliveries on export account have never been so large in any month in the history of the trade, and traders are agreeably surprised to see the shipments so well kept up in June, which is usually a quiet shipping period. It was hardly expected that the figures for May would have been exceeded. Germany has taken 10 per cent. more than last month, but Scotland has received less Cleveland iron, the prices being higher than consumers there are prepared to give, especially as cheaper iron is forthcoming from other quarters. The shipments of the first half of this year exceed those of any half year on record, but it is doubtful whether they will be kept up at such a rate during the second half of the year. The quantity shipped in June up to 27th was 120,902 tons, as compared with 119,002 tons last month; 82,078 tons in June, 1905; and 65,055 tons in June, 1904, all to 27th. Italy is receiving considerable quantities of hematite iron from the Tees, and there is fair shipments of this quality to the United States and Canada.

Manufactured Iron and Steel.

While works are kept well occupied on old contracts, there is very little disposition to give out any more at present, and inquiries are very few. That producers are not badly situated for work, and that there is as yet no necessity for them to seek for orders, can fairly be inferred from the fact that they are not reducing their quotations, even the prices of plates and angles being kept up, though some of the makers complain that the shipbuilders are backward about furnishing the specifications for the steel which they have bought. Not less than £7 will be taken for steel ship-plates; £8 for steel boiler-plates; £7 5s. for iron ship-plates; £6 12s. 6d. for steel ship angles; £6 for packing iron; £7 17s. 6d. for iron ship rivets, all less 2½ per cent. f.o.t. A good tonnage of shipbuilding material is being sent from this district to Germany and Denmark. Bar manufacturers are fairly well off for orders and keep the price of iron bars at £7 5s., and steel bars at £7, both less 2½ per cent. f.o.t. Steel rails are in better request, and at least £6 7s. 6d. net f.o.t. must be paid for them. For chairs and sleepers the orders are few, and the prices are hardly so firm as they are for rails. The bulk of the steel sleepers now wanted are for India, to which the deliveries of all kinds of manufactured iron and steel from the Tees this month are very large, as they are also to Japan.

Shipbuilding and Engineering.

Shipbuilders are clearing off their orders much more rapidly than they are booking others to replace them. For some time there has been an almost complete absence of fresh contracts for new steamers, and that cannot be surprising when the state of the freight market is taken into account. The outlook is far from encouraging for the owners of tramp steamers, and a good many of these even now are not earning enough to cover cost of running. The promises of better times for shipowners so generally reported in the early part of the year are not being fulfilled. There is an order on the market for twenty steamers for the Brazilian Lloyd's Company, which is renewing its fleet. The order includes ocean, passenger, and cargo steamers, as well as river and coasting boats. Marine engineers have plenty of contracts on hand, but fresh orders are few.

Railway Bridge over the Tees.

The North-Eastern Railway Company has decided to renew the superstructure of the bridge carrying the passenger lines over the river Tees at Thornaby, and they will also erect a new steel bridge of five spans of a total length of 340ft.

A Zinc Works on Teesside.

A London firm of zinc manufacturers has purchased a large tract of reclaimed land from the Tees Conservancy Commissioners, on the north bank of the Tees, opposite Middlesbrough, for the purpose of building a zinc manufactory.

Cleveland Miners' Wages.

The Executive Council of the Cleveland Ironstone Miners' Association have decided to ask the employers for a substantial advance in wages, but will not press the question of a twelve o'clock Saturday for mechanics at the mines.

North-Eastern Railway Wages.

Though a good deal of dissatisfaction has been expressed by various sections of the men, it is expected that the concessions offered by the company will be accepted, and the proposal to form a permanent Conciliation Board, to deal with grievances as they arise, is generally favoured; in fact, the Executive Council are urged to approach the company on this matter.

Coal and Coke.

The coal trade shows considerable improvement, and branches which are usually at their slackest at this period of the year are doing well. The Durham gas coal business is very active, and satisfactory orders are coming forward from the Continent. Thus there is not in this branch the customary slackness noticeable about midsummer. For next year's delivery, 10s. 3d. to 10s. 6d. f.o.b. is quoted for best gas coals, and for seconds 9s. 6d. Steam coal is in good request, but this week, in the Newcastle district, the race holidays have lessened the production, and supplies are scarce. For best steam 10s. 6d. f.o.b. has to be paid, and seconds are 9s. 9d. to 10s. Bunker coals are in brisk demand, and owners of steamers are paying 9s. to 9s. 3d. f.o.b. for unscreened. Coke also is dearer, the over-production having been corrected by a reduction in the output, and 17s. per ton is now obtained for medium coke, delivered at the Middlesbrough furnaces, while 18s. 6d. f.o.b. is the price of best foundry coke.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General State of Trade.

THE general condition of trade does not appear to have undergone any material change since last report. In the leading branches of manufacture there is steady employment, with contracts existing that will keep the works going for a considerable time to come. As regards the great shipbuilding industry, it is noticeable that the fresh work coming to hand at the moment is inadequate to take the place of that being completed, but it has to be remembered that we are on the eve of the trade holiday season,

when new orders are only placed in exceptional circumstances. On the whole, therefore, the trade position may be regarded as fairly satisfactory.

The Warrant Market.

There has been a steady feeling in the Glasgow pig iron market, with a moderate business. Reports are current as to further very considerable purchases of Cleveland iron for shipment abroad, and these have not been without their influence on the market. Business has been done in Cleveland warrants at 49s. 9d. to 50s. cash, and 50s. 2d. for delivery in one month. Scotch warrants have been at 56s. 6d. to 56s. 3d. cash; Cumberland hematite, 64s. 7½d.; and standard foundry pig iron, 49s. 10½d. per ton.

Scotch Hematite Iron.

There is a large current production of this class of iron, the makers evidently having every confidence that it will all be required in due time, although a somewhat easier feeling has been reported in the market within the last few days. Prices are practically unaltered, merchants quoting 69s. 6d. per ton for delivery at the West of Scotland steel works.

Output and Stocks of Pig Iron.

There are 88 furnaces in blast in Scotland, compared with 85 at this time last year, and of the total 45 are making hematite, 37 ordinary, and six basic iron. While the current business in pig iron is moderate, makers have every prospect of disposing of their output on satisfactory terms. The stock of pig iron in Glasgow warrant stores shows a decrease for the past week of 143 tons. The stores now contain 12,086 tons ordinary and 6650 tons standard foundry pig iron.

Scotch Makers' Pig Iron Prices.

In one or two cases the prices of the special brands of Scotch pig iron show a reduction since last week of 6d. per ton. G.M.B., No. 1, is quoted at Glasgow 57s. 6d.; No. 3, 55s. 6d.; Monkland, No. 1, 58s.; No. 3, 56s.; Carnbroe, No. 1, 61s.; No. 3, 58s.; Clyde, No. 1, 65s.; No. 3, 60s.; Gartsherrie, No. 1, 65s.; No. 3, 60s.; Calder, No. 1, 66s.; No. 3, 61s.; Summerlee, No. 1, 68s.; No. 3, 63s.; Langloan, No. 1, 69s.; No. 3, 63s.; Coltness, No. 1, 73s.; No. 3, 62s.; Glengarnock at Ardrossan, No. 1, 66s.; No. 3, 60s.; Eglinton at Ardrossan or Troon, No. 1, 60s.; No. 3, 57s. 6d.; Dalmellington at Ayr, No. 1, 62s. 6d.; No. 3, 57s. 6d.; Shotts at Leith, No. 1, 66s.; No. 3, 61s.; Carron at Grangemouth, No. 1, 67s.; No. 3, 62s. per ton.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 5589 tons, compared with 5068 in the corresponding week of last year. There was shipped to the United States 25 tons, Canada 80, South America 135, India 50, Australia 655, Italy 360, Germany 165, Russia 25, Holland 120, Belgium 30, China and Japan 283, other countries 300, the coastwise shipments being 3369 tons, against 2524 in the same week of 1905. The total shipments for the year to date amount to 141,948 tons, being 2442 tons more than in the corresponding period of last year.

Arrivals of English Iron.

The arrivals of pig iron at Grangemouth from the Cleveland district in the past week were 10,485 tons, being 4222 tons less than in the same week of last year. There is, however, a total increase in these imports for the year to date amounting to 16,250 tons.

The Steel Trade.

The chief matter of interest at the moment in the steel trade is that of competition between English and Scottish makers, which has recently been the means of a great deal of discussion and negotiation. Representatives of the English and Scotch makers meet at Carlisle on Friday, when it is hoped some satisfactory arrangement may be reached. It is said that there is substantial agreement that the districts hitherto competing so keenly to the detriment of both, in the matter chiefly of prices of angle steel, should be reserved, Scotland to the Scotch and England to the English makers; but the report goes that as regards Belfast, where an important trade is done with the shipbuilders, there has been some difficulty in coming to an arrangement. Business has been done, it appears, at low rates to such an extent that makers, north and south, are represented as anxious to reach a settlement that would prevent unprofitable cutting of prices in future.

The Finished Iron Trade.

The makers of malleable iron in this district have had the state of the market and prices under review. A considerable business has been offering for shipment to the East, but the makers have not been inclined to accept the rates offered, although there appears to be an expectation that parties may eventually come to terms. Prices of malleable iron generally are unchanged, but offers were made to tube-makers to make a reduction in both iron and steel strips and hoops, provided orders were placed within a few days, after which the former rates were to prevail. It is stated that with the exception of only one firm, consumers were prepared to take advantage of this offer and book their orders.

The Shipbuilding Trade.

The new work at present coming forward is not very large; but several good orders for abroad are expected to be placed soon on the Clyde.

The Coal Trade.

Business is fairly active in the different branches of the coal trade. While shipments are not quite so large as in the preceding week, they compare favourably with those of this time last year. The inland demand for home use and industrial purposes is well maintained, and prices are quoted without material change.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The State of the Coal Trade.

STEAM coal continues the chief quality in demand. One can see in most districts, at collieries and railway sidings, a few trucks of house coal, Monmouthshire predominating, but the chief coals are steam, and for these there has been no slackening in demand. Last week the principal ports were busy. Several days Cardiff, Penarth, and Barry had a long list of clearances; Newport continues its high averages by despatching over 90,000 tons, and Swansea nearly totalled 60,000 tons. Mid-week the report on 'Change, Cardiff, was that new business was restricted, owing to the heavy engagements entered into for delivery up to the middle of July. Very best Admiralty qualities are very firm, and owners quote 16s. 3d. freely. Ruling quotations are:—15s. 9d. to 16s 3d. for best; and best seconds are very firm at 15s. to 15s. 6d.; seconds, 14s. 6d. to 14s. 9d.; drys, 13s. to 13s. 3d.; best washed nuts, 12s. to 12s. 6d.; seconds, 11s. 6d. to 11s. 9d.; best washed peas, 11s. to 11s. 3d.; seconds, 10s. 3d. to 10s. 6d.; very best smalls, 9s. 9d. to 10s.; best ordinaries, 9s. 3d. to 9s. 6d.; seconds, 8s. 6d. to 9s.; inferiors, 8s. to 8s. 3d. Monmouthshire semi-bituminous:—Very best large, 15s. to 15s. 3d.; best ordinaries, 14s. to 14s. 3d.; seconds, 12s. 6d. to 13s. 3d. House coals:—Best, 15s. 3d. to 15s. 6d.; best ordinaries, 14s. to 14s. 6d.; seconds and other kinds, 11s. to 13s.; No. 3 Rhondda, 15s.; brush, 13s.; smalls, 11s. to 11s. 3d.; No. 2 Rhondda, 10s. 9d. to 11s. Patent fuel, 16s. to 16s. 6d. Coke, 17s. to 25s. Pitwood firm at 21s. 9d. to 22s.

Anthracite Coal.

In the Swansea district an improvement is recorded:—Best malting is quoted at 17s. 6d. to 18s.; seconds, 16s. to 17s.; big vein, 12s. to 12s. 6d.; red vein, 9s. to 9s. 6d.; cobbles, 17s. 6d. to 18s.; nuts, 17s. 9d. to 18s. 6d.; peas, 11s.; culm, 6s.; duff, 4s. 6d. Steam coal is quoted at 15s. to 16s.; No. 3 Rhondda at 14s. 6d. to 14s. 9d.

The Non-Unionist Difficulty.

As I had anticipated, there has been a considerable number of outstanding arrears paid up by the colliers, who objected, in the Cyfarthfa and Plymouth districts, to pay to the federation. Some still remain out, and though it is stated that contracts will be regarded as terminated on Saturday next, unless all join, there is every likelihood of a peaceful settlement.

Tynewydd Repeated.

There was an inrush of water this week in a colliery "stant" known as Caradox Vale, near Hendre Fagan Railway Station. The colliery is worked by a French company. On Tuesday the inrush took place in the drift, and after the outward rush of the men had ceased it was found that six men were entombed, and the prospect, as I write, is regarded as very serious, if not hopeless.

Irregular Practices in Welsh Mines.

Mr. J. E. Martin, Inspector of Mines, calls attention in his annual report to irregularities in Welsh mines. In some he has found the practice of using naked lights continued, and he comments upon the gravity of a course of things likely to be attended with serious results. The special rules in force respecting "falls" in collieries had now had twelve months' trial, and he commended highly managers and coalowners for the attention given. In respect of haulage, he regrets that South Wales and Monmouthshire had a bad record, and the description given by him of the large and heavy trams, the broken roads, and their deep muddy character, is one certain, one will expect, to be noted and corrected. One of his most important comments refers to repairers, and the folly of stopping them shown by men on strike.

Iron and Steel Trades.

A leading incident of the week has been the receipt in Newport of about 4000 tons of steel billets from New York and of several cargoes of German billets from Antwerp. There is, fortunately, no falling away in local enterprise, depressing as the competition of America and Germany is. The Welsh ironmasters are not abating in vigour, the influx of ore from Spain is continuous, and the developments at Dowlais and Ebbw Vale in particular are of the highest order. One "parcel" of steel rails and fish-plates came to Cardiff from Harrington, and, on the other side, a large cargo of rails left Newport for Bahia. Mills have been tolerably busy with home and colonial rails, both light and heavy figuring; "finished" goods bulked largely last week; fish-plates and angles were turned out freely, and billets in moderate quantities. Mid-week over 5 00 tons iron ore came to Ebbw Vale from Agua Amarga and Castro Urdiales. Blaenavon and Cyfarthfa are also busy importing ore. In the Swansea district the steel trade is in a healthy condition, and the principal works have bar orders in hand that will take some time to complete. On 'Change, quotations for Bessemer pig iron, mixed numbers, are 64s. 7½d.; Middlesbrough, 49s. 8½d.; Scotch, 56s. 3d.; and Welsh hematite, 70s. to 71s. Steel bars remain at £5, both Siemens and Bessemer. Iron ore, Cardiff and Newport, 18s. 9d. to 19s. for Rubio, 18s. 9d. for Almeria.

Unusual Incident in Tin-plate.

A suggestive incident has occurred in the tin-plate districts—the receipt of a large quantity of returned tin-plates from Russia. This shows an almost hopeless condition of things, and indicates, at least, that a recovery of trade is yet some way off.

The Far East Tin-plate Trade.

I am glad to note that, as a contrast to the slackness in Russian trade, prospects in the Far East are improving. A few days ago, at Swansea, the Ching Wo, for China and Japan, loaded 2600 tons of tin-plates, galvanised sheets, &c. A tolerable quantity of tin-plates is also loading for South America, Italy, Holland, France, and Rio. Spain and Denmark are also buyers. Last week the total shipments were still below the averages that were recorded before the holidays, only 44,986 boxes being despatched. Per contra, the quantity received from the works was large, amounting to 70,000 boxes; no stocks now show great accumulation, and are at present over 207,000 boxes. As remarked on 'Change this week, the outlook is gloomy, but with tranquil labour prospects a turn in the tide is possible.

Tin-plate Prices.

Mid-week on 'Change, Swansea, tin-plate prices were stated to be nominal; ordinary plates, I.C., 20 by 14, 112 sheets, are quoted at 13s. 1½d. to 13s. 3d., Bessemer; while Siemens are given at 13s. 4½d. C.A. roofing sheets are at £9 per ton. Big sheets for galvanising, 6ft. by 3ft. by 30 gauge, £9 7s. 6d. Finished black plates, £9 10s. Block tin is at £176 15s. Lead, £16 17s. 6d. Copper, £81 5s. Silver, 30d. per oz. Spelter, £27 2s. 6d.

Associated Industries.

Copper trade is reported as holding its own, and regular employment is prevailing at Morfa, Middle Bank, and Hafod. Spelter works are busy; Mannesmann Tube Works actively employed principally on 8in. to 12in. tubes. Foundries and engineering works brisk.

Tin-plate Settlement.

A satisfactory arrangement has been brought about between employers and men, and the "list" is to be maintained for another year. At a meeting in Swansea on Saturday Mr. John Hodges paid a warm tribute to the chairman, Mr. Trubshaw, for his bringing about the arrangement and for his statesmanlike administration.

Llanelly Trade.

There is still scope for improvement in the tin-plate trade of this district. As stated in connection with the trade of Swansea last week, the holiday has not been followed by the much needed briskness of demand, and this week it was stated that several works are going on altogether on black-plate. The steel trade is better, and demand from the Midlands is continued. In the matter of anthracite, a steady improvement is shown, and the demands from France and Germany are well maintained.

The Rhymney Iron Company.

The annual report of the directors shows a profit for the year ended March of £41,495 15s. 9d. A dividend of 2 per cent. free from income tax was recommended. The quantity of coal raised during the year was 798,230 tons, against 783,531 tons for 1905. The market for steam coal was reported as satisfactory. The make of coke was 41,380 tons against 40,307 tons, all of which was sold at satisfactory prices. With regard to future business it was reported that the sinking of the Groesfaen pit had been completed, and the steam measures reached at 698 yards. A connection with the Penycarrey pit has been completed, coal reached at Pengarn at a depth of 315 yards; a junction connecting the new sidings with the Brecon and Merthyr Railway Company's main line put in; and at the new Duffryn pit the work of proving the lower four feet continued. Under the able management of Mr. Smith prospects continue very favourable.

The Barry Railway Bill.

In the House of Commons Committee this week the Barry Railway Bill was ordered for third reading.

Great Western Railway Movement in Pembrokeshire.

In Swansea this week 200 navvies were engaged, as the result of advertisements for hands, and sent by free pass into Pembrokeshire. As showing the abundance of spare labour amongst this class, fully 500 men presented themselves.

Milford and Manchester Railway.

The leasing of this line by the Great Western is now stated to be completed. In the district the undertaking is regarded with favour, and a vigorous policy is expected, with increased facilities and other public benefits.

NOTES FROM GERMANY.

(From our own Correspondent.)

From Rheinland-Westphalia.

SINCE last week's report no change that would be worth mentioning has taken place on the Rhenish-Westphalian iron and steel market, business transactions remaining satisfactory as before. Plenty of fresh work has been coming in, and the iron and steel-producing establishments are all engaged to their fullest capacity. Though the output in pig iron is larger than ever, it is hardly sufficient to cover the steadily increasing demand, and the number of blast furnaces, therefore, is going to be raised; about twelve blast furnaces are reported to be in course of construction, and the increase in output is estimated to amount to about 1,000,000 t. The Pig Iron Convention, at a recent meeting, has withdrawn the decision regarding the abolition of the export bounty, and is going to grant the bounty, as formerly, during the third quarter of present year, under condition, however, that the Coal Convention likewise continues to grant the above-mentioned bounty. Also in semi-finished steel consumption is heavier than output, and here, too, extensions of existing establishments, as well as the building of new steel works, has been taken into consideration. A further improvement can be reported from the scrap iron market both as regards demand and prices. The question of prolonging the Steel Convention has been to the fore lately; at a meeting that took place on the 31st of last month it was proposed to prolong the Convention, which ends on June 30th, 1907, for another year, but the more far-seeing members of the Union request a prolongation for at least several years. In the girder and sectional iron department production is readily consumed, and the bar trade shows quite an exceptional briskness for this time of the year. The condition generally on the plate market may be regarded as satisfactory, even though the costs of production have increased for the "pure" rolling mills; they are still working with a fair profit, and the outlook is pretty favourable, too, activity in the shipbuilding and boilermaking departments increasing steadily. Many mills have secured work till autumn, and some can boast of having orders on their books till far into the last quarter of the present year. Wire and wire nails sell freely, and at paying prices.

Upward Tendency in the Siegerland.

Though prices have met with considerable advances since early spring, the number of orders coming in at the iron and steel works increases from week to week: the tone, therefore, is exceedingly firm, and an upward movement is generally perceptible. The works, in a number of cases, have booked orders till far into the fourth quarter. A very large demand is experienced in the semi-finished steel trade, where consumption is, on the whole, higher than output. For bars, M. 130 p.t. has been asked; sheets stand on M. 145 p.t., and for large orders only slight concessions are agreed to. Heavy plates have realised M. 135 p.t. at recent sales, and for galvanised articles, too, higher prices are quoted.

Iron and Steel in Silesia.

Very good accounts can be given of the business done in the various branches of the Silesian iron industry. More orders have been coming in lately than at any other time of the year, and the shops and factories are all very actively engaged, the structural iron and engineering departments being particularly well occupied. Quotations, though exceedingly firm, have not moved in an upward direction, but there may be a rise, here and there, for articles specially well inquired for, in autumn.

The German Coal Trade.

The aspect, generally, of the coal and coke trade over here has not altered since previous letters, showing strength and briskness in all districts. Coal for coke making is rather scarce, and will most likely meet with an advance in price. The number of men in the Rhenish-Westphalian district is still insufficient, and there is but little chance of securing more hands at the pits when all the iron and allied industries are so vigorously engaged. From the Government collieries on the Saar a number of men are reported to have gone to the Ruhr coal district, but the managers of the Saar pits have officially announced that these colliers are not likely to find employment again at the Government pits, should they return.

Austro-Hungarian Iron Industry.

The business in pig iron continues very firm, and for heavy plates and sheets a good demand has likewise been coming in, but girders, as well as bars, have been showing some weakness lately. Satisfactory employment is reported to continue at the foundries and machine factories. Engine fuel sells freely in Austria-Hungary; house coal has been fairly quiet, but prospects all round are improving. The sugar mills are expected to purchase largely later on.

Condition of the French Iron Trade.

Plenty of fresh work is stated to have come in on the French iron market in the course of the past week, but the strike in Paris has, of course, checked transactions considerably in many cases, and a number of orders have been going to foreign firms which would have helped to keep the inland works in brisk employment. The general tendency, however, is firm. Stiffness in price and an active demand are the characteristic features of the French coal market. During the last week an upward tendency in quotations could even be perceived.

From the Belgian Iron Market.

All the principal trades are reported in excellent employment, and fresh orders come to hand freely. An increasing firmness as regards quotations is perceptible also for those articles that had been somewhat neglected until now. The following prices have been fixed for bars in iron:—No. 2, 142·50f. p.t. for export, and 155f. p.t. for inland consumption; No. 3, 145f. p.t. for export, and 157f. p.t. for inland consumption. Steel bars are quoted 147·50f. p.t. for export, while inland quotation is 160f. p.t. Higher prices than those above quoted are hardly obtainable. In plates a good business is done at the following prices:—

	Export. Francs.	Inland. Francs.
Iron plates, No. 2, and steel plates ..	160	170
Iron plates, No 3	165	175
Siemens-Martin plates	170	180

Increasing Activity on the Belgian Coal Market.

A most lively business has been transacted in the coa districts of Belgium during this week and the last, and the tendency of prices is decidedly upwards. Dry sorts of coal meet with exceptionally good request, so do briquettes; and coke, which sells very freely, is firm at 23f. to 26f. p.t., consumption being rather heavier than output.

BRITISH PATENT SPECIFICATIONS.

Selected and Abridged by **JAMES D. ROOTS**, *M.I. Mech. E.*

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-Office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

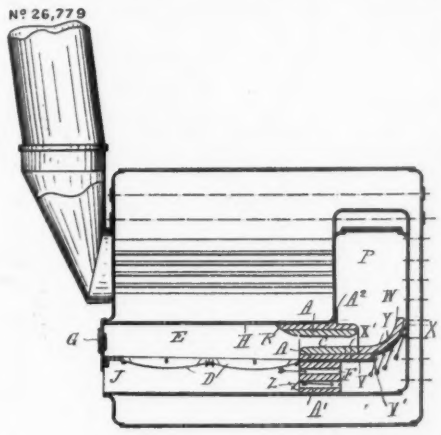
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-Office of opposition to the grant of a Patent.

STEAM ENGINES AND BOILERS.

26,779. December 22nd, 1905.—IMPROVEMENTS IN FURNACES FOR STEAM GENERATORS, *Clifford John Johnson, of Point Chevalier, near the City of Auckland, New Zealand, and James Carlaw, also of Auckland.*

This invention relates to improvements in furnaces for steam generators of the kind in which the fire chamber and ashpit are separated from the flue or continuing part through which the products of combustion pass to the chimney by a wall or diaphragm having openings above the grate bars for the products of combustion from the fire chamber, and other openings below the grate bars for highly heated air from the ashpit to pass through into the flue, where the products and heated air mix so as to cause any carbonaceous matters in products to be burnt. This invention consists in a peculiar construction of the wall or diaphragm whereby better results are obtained. There is one figure and a section. E represents the flue tube; H the fire chamber; J the ashpit; P the flue continuing part or combustion chamber; A the wall or



diaphragm composed of an upper bridge A^2, extending to the crown of the fire chamber and a lower bearer part A^1; C, F, the passages through the diaphragm respectively leading from the fire chamber and the ashpit to the flue; D the furnace grate bars; and G the fire-box door. The top part of the bridge A^2 is extended well into the fire chamber H, and the underside of such extension is gradually sloped away, as at R, from the top level of the inlets to the fire gas passages C, to the crown of the fire chamber, so as to more gradually deflect the fire gases from the crown of the chamber; and the lower part, V, of the bridge is extended well into the combustion chamber P, the part V^1 thereof forming the floor of the passages C, being extended further into the chamber P in the form of an up-curved projection W. Passages X^1, Y, are formed through the projecting parts, and a passage X is left between the projection W. and the back of the chamber P, through which passages the hot air from the ashpit issuing through the passages F obtains access to the gaseous products from the fire chamber issuing from the passages C. The extension V and up-curved projection W of the bed of the bridge serve to prevent the furnace gases issuing from the passages C from passing downward and to cause the hot air issuing through the passages F to have an upward direction.—*May 24th*, 1906.

TURBINES.

9769. April 26th, 1906.—IMPROVEMENTS IN ELASTIC FLUID TURBINES, *George Westinghouse, of Westinghouse-buildings, Pittsburg, Pennsylvania, United States of America.*

This invention relates to elastic fluid-pressure turbines. It has been found in practice that the rotors and stators of elastic fluid-pressure turbines are liable to and do distort under certain conditions. It is essential to the efficiency of such machines to have the clearances between the relatively moving parts as small as possible in order to diminish leakage. Fig. 1 is a view partially in section and partially in elevation of a fragmentary portion of the

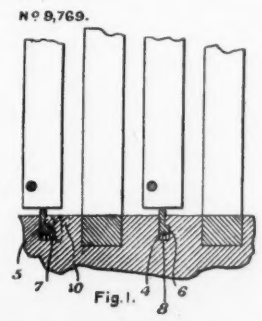


Fig. 1.

turbine equipped with this invention; in this view the blades or vanes, as the case may be, are shown unshrouded, but lashed together by any suitable means. The holding element for holding the blades or the veins, which may be either the rotor or the stator, is provided with circumferential undercut slots or channels 4 in line with the rows of blades or vanes carried by the other holding element, which may be the rotor or stator. In these slots or channels 4 a segmental ring 5 is threaded. This ring is provided with a flange portion 6, which lies within the undercut portion of the channel below the overhung portion 7, which overhung portion serves as an abutment for limiting the outward radial movement of the ring. A spring 8 of any suitable form lies within the channel beneath the ring 5 and tends to yieldingly hold the ring so that its flange 6 lies in contact with the overhung portion 7 of the channel. As the turbine casings or stators are commonly divided on the horizontal plane through the turbine axis, these ring segments 5 are easily inserted within the channels of the stator. If they are employed on the rotor, however, it will be necessary to have a section of the overhung portion 7 removable—as at 10 in Fig. 1, and the length of this removable portion will have to be slightly longer than the segments of the ring 5. This removable portion 10 may be secured in place by screws or other suitable means. It will be understood that by employing this device in a turbine the clearances beyond the ends of the blades or vanes may be reduced to a minimum, and the top edge of the ring 5 may just lie out of contact with the ends of the blades or vanes, or the shroud with which they may be provided. If distortion does occur and the blades or vanes contact with the ring, the same will yield and move outwardly to accommodate such distortion.—*June 24th* 1906.

767. January 11th, 1906.—IMPROVEMENTS IN OR RELATING TO FLUID-PRESSURE TURBINES, *Oskar Richter, of Bismarckstrasse, Munich, Germany.*

This invention relates to a combined impulse and reaction turbine for elastic fluids, and has for its primary object to provide improved means for balancing axial thrust on the turbine shaft. In this invention the high-pressure part of the turbine is formed as a partially expanded impulse turbine, the middle and lower-pressure part as a reaction turbine. The blades of the impulse part are of a larger diameter than those of the reaction part. From the point where one part passes into the other the diameter of the reaction

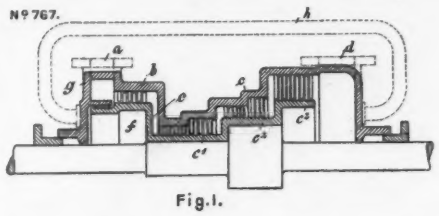


Fig. 1.

part increases towards the end. Fig. 1 is a section; *a* is the coupling piece for the steam supply pipe, *b* the impulse part, *c* the reaction part of the turbine, and *d* the coupling piece for the exhaust outlet. The step between the impulse and reaction part due to the difference in diameters forms an annular surface *e* for completely relieving the shaft from axial thrust. The reaction part is formed with three stages, c^1, c^2, c^3, increasing in diameter, the front blades of the first two stages being smaller than the rear blades of the same. The stage c^3 carries the largest blades, in view of the increased volume and diminished pressure of the steam. In order to fully balance the axial pressure, the front side of the casing *g* is connected by a pipe *h* with the exhaust steam outlet connection *d*.—*May 24th*, 1906.

RAILWAYS AND TRAMWAYS.

15,223. July 25th, 1905.—IMPROVEMENTS IN OR CONNECTED WITH CHAIR KEYS FOR THE PERMANENT WAY OF RAILWAYS AND TRAMWAYS, George Napier, jun., of 101, Paynes-road, and Andrew Napier, of 95, Hill-lane, both in the County Borough of Southampton.

This invention relates to metal keys of that type in which the key is made in two pieces pushed apart by a wedge, or inclined surfaces for use in securing metal rails in their chairs, and has for its object to provide a simple metal key to take the place of the ordinary wood keys that can be locked in the chair and be tightened as required, and capable of easy removal. Fig. 1 shows

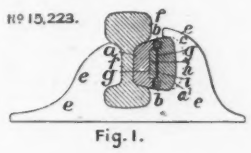


Fig. 1.

in end section a rail with chair key. Fig. 2 is a sectional plan. *a* a^1 designate the two longitudinal parts forming the metal chair key, and *b* denoted the morticed studs by which the parts *a* a^1 when placed together correspond in size and outer form to the ordinary wood key used to secure rails in their chairs. On the part a^1 is provided a lug or projection *c* at one end, and a projecting key at the other end, which fit and receive the metal of the chair *e*, and lock the key *a* a^1 longitudinally in the chair *e*. To tighten the key *a* a^1 between the chair *e* and the rail *f*, a groove *g* is formed with a slight taper on each meeting inner surface of the parts *a* a^1, and we provide a metal or other wedge *h* of size to correspond with the grooves *g* when the parts are together. One of the surfaces of the combined grooves *g*, and the metal wedge *h*, are serrated, notched, or stepped with teeth *l* so that when the

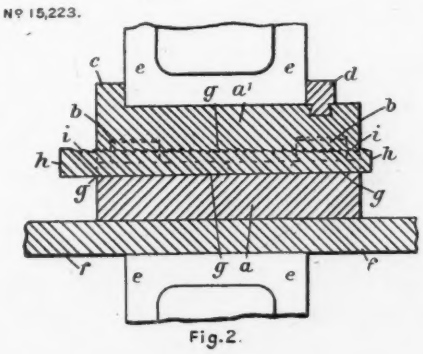


Fig. 2.

wedge *h* is driven in the teeth engage with the teeth on the surface of the groove *g* in the chair, and the parts *a* a^1 of the chair key are separated and expanded as the wedge *h* is driven in, and the rail *f* is thereby fixed in the chair *e*. When placing the key parts *a* a^1 between the chair *e* and the rail *f*, the projecting key or wedge *d* is first removed from the part a^1 of the chair key, and the chair key is placed in position and the projecting wedge *d* replaced, thus fixing the chair key *a* a^1 longitudinally in the chair *e* by the lug *c* and key *d*, then by driving in the toothed wedge *h* between the parts *a* a^1 of the key, such parts are slightly separated, and the key is tightened between the rail *f* and the chair *e*, and locked by the teeth of the wedge *h* engaging with the teeth on the surface of the groove *g*.—*June 24th*, 1906.

ORDNANCE.

17,089. August 23rd, 1905.—IMPROVEMENTS IN APPARATUS FOR TESTING THE ALIGNMENT OF GUN SIGHTS, Sir W. G. Armstrong, Whitworth and Co., Limited, and Commander Joseph Honner, R.N., all of Elswick Works, Newcastle-on-Tyne.

This invention has for its object an instrument designed to afford a ready means of testing the alignment of gun sights, at any elevation, without the aid of fixed targets on shore or on board ships. It is especially useful for broadside guns, which cannot be aligned on fixed targets unless the ship is alongside a wharf or in dock. Fig. 1 is a front elevation, and Fig. 2 a side elevation. The apparatus is carried by a muzzle plate *a* with adjusting slots or windows *b*, and having fixed to it a split tompion *c*. This arrange-

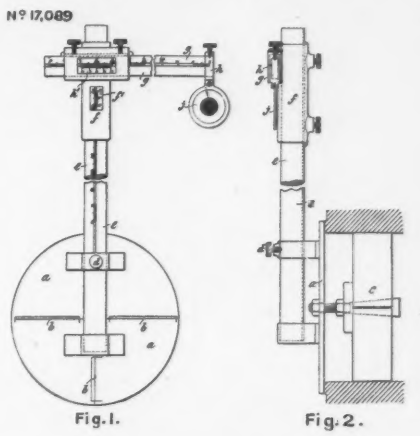


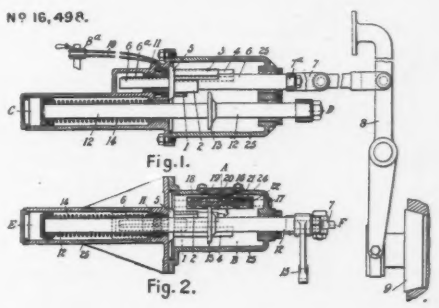
Fig. 1. Fig. 2.

ment of muzzle plate, split tompion, and adjusting slots enables the instrument, including the muzzle plate, to be used in any calibre of gun by substituting a split tompion to suit the calibre. The windows *b* allow the horizontal and vertical diameters usually marked on the muzzle of the gun to be seen, so that the plate can be accurately placed in position. Clamped to the muzzle plate *a* by a screw *d* is a vertical upright *e*, having on it a sliding collar *f*, provided with a socket in which a horizontal arm *g* is free to slide. This horizontal arm has upon it a slide *k* carrying a miniature target *j*. The vertical and horizontal arms are graduated, and the slides are provided with verniers f^1 and k^1. The horizontal bar *g* is graduated so that it can be set to enable both the right and left-hand sights of a gun or turret to be adjusted at the same time, the necessary number of targets being used for the purpose.—*June 24th*, 1906.

ROAD MOTOR VEHICLES.

16,498. August 14th, 1905.—IMPROVEMENTS IN CONTROLLING MECHANISM FOR MOTOR ROAD, AND CERTAIN OTHER PROPELLED VEHICLES, Charles Humphrey Humphreys, of Court Prior, Torquay, and Scowen, Limited, of 84A, King's-road, Reading.

This invention relates to improvements in controlling mechanism for motor road and certain other propelled vehicles, such as those running on rails and having a change-speed mechanism. As is well known in such vehicles where two or more speeds are provided, care must be taken to put the driving clutch out of action firstly, and then to change the speed step by step—that is, to change from one speed to the next, and so on by separate operations, since to change from one speed to another with the clutch in usually results in breakage of the teeth of the gear wheels, and to change from the lowest to the highest, or *vice versâ*, at once, may also result in breakage. This invention consists not only in providing means whereby the gears cannot be changed without opening the clutch, but wherein the act of so doing will alter the gear step by step when so desired in the upward movement is obtained by means of a slidable part or parts connected with the clutch and with the change speed gear, and having on its forward movement the action of a pawl or a ratchet or like step by step movement,



which movement is utilised by the speed-setting device or indicator. Fig. 1 illustrates a part sectional side elevation of the controlling mechanism. Fig. 2 is a part sectional plan. This construction comprises a link 7 attached to or connected with the usual foot lever or pedal 8 controlling the clutch, indicated partly at 9, so that it is moved therewith. This link 7 is in turn connected with a shaft 6 having a slidable movement in a casing. The shaft 6 is a primary shaft, which has cut or formed thereon a number of steps 1, 2, 3, 4, which represent the different speeds, and also a circular collar or shoulder 5 having an inclined face, which represents the reversing movement. The shaft 6 obtains its sliding motion in the forward direction by the operation of the pedal and in the reverse direction by means of the usual clutch spring. The shaft has also a rotary movement in both directions, which may be conveniently effected by means of bevel or other gearing, or by means of a flexible connection, such as by Bowden wires 10, wound about a drum 11 in opposite directions, and having their ends secured to such drum, which is mounted on the shaft 6 upon a feather 6a, so that the shaft is free to slide with respect to the drum, which flexible connections are attached to the lever of a speed-setting device or indicator 8a. The rotary movement of the shaft with respect to the link 7 is permitted by the yoke and nut connection 7a. A secondary slidable shaft 12 is mounted parallel to the shaft 6, and is provided with a collar 13 or other suitable projecting part, which is adapted to engage the steps 1, 2, 3, 4 on the shaft 6, whereby the shaft 12 is actuated in one direction, movement in the reverse direction being performed by a spring 14. This shaft 12 is connected either directly or through the link 15 with the sliding pinions in the gear-box itself. Above the shafts 6 and 12 is mounted a ratchet plate 16, preferably hinged as 17, which plate is provided with a number of teeth or the

like corresponding with the number of speeds in the gear-box. Five teeth are shown, 18, 19, 20, 21, 22, and these teeth are arranged on the plate 16, so as to project into the path of the collar 13 on the shaft 12, whilst a further tooth or projection 23 having an inclined face is arranged on the plate 16 nearer to the hinge 17, so as to project into the path of the collar 5 on the shaft 6, which thereby controls the movement of the ratchet plate 16. The ratchet plate may also be provided as shown with a spring 24, which keeps it in its normal position.—*May 24th*, 1906.

PNEUMATIC HAMMERS.

23,435. November 14th, 1905.—IMPROVEMENTS IN PNEUMATIC HAMMERS, Thomas Scott King, M.I. Mech. E., of 43, Eastbourne-road, Penarth, Cardiff, and William Norris, of 20, Osborne-road, Blackpool.

This invention has for its object to provide an improved pneumatic hammer which shall be more simple and efficient in operation and construction. This invention consists in a pneumatic hammer in which compressed air is admitted to the cylinder for the purpose of raising the hammer tup, and the blow is effected by the expansion of the air which has been used for raising the tup. Fig. 1 is an elevation of a pneumatic hammer according to invention, the valve being shown in section. The hammer frame *a* is of the general form well known as applied to steam hammers, while

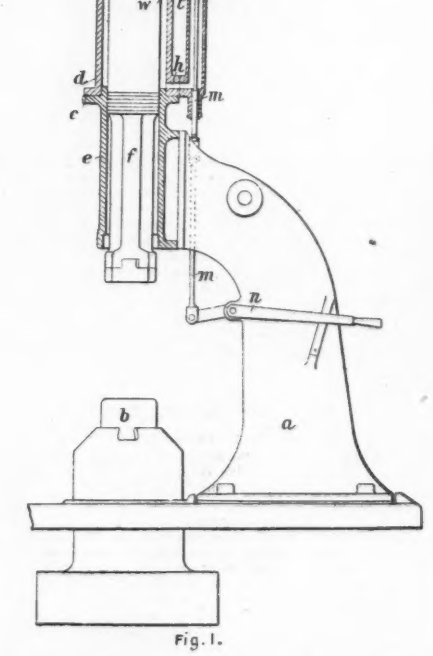


Fig. 1.

the anvil *b* is firmly founded. The hammer cylinder *c* is of considerable length, and is bored out to two diameters. The upper part *d*, of larger diameter, constitutes a working cylinder, while the lower part *e* acts as a guide to the hammer tup *f*. In the upper part there works a piston *g*, formed on the tup *f*, so that below this piston and around the tup there is formed an annular space. Into this annular space, near the lower end of the working cylinder *d*, there enters pipe *h*, leading from a valve chamber *j*, in which works a piston valve *k*, adapted to control the supply of air to the working cylinder and operated in any convenient way by hand. The valve is operated by the usual mechanism employed in connection with steam hammers—that is, by means of a rod *m* and operating hand lever *n*. The valve chamber *j* is provided with an inlet *o* and an exhaust passage *p*, both of which passages lead to annular recesses *q* and *r*, respectively formed around the valve chamber. A liner *s*, having ports cut therein, is provided within the valve chamber, while the valve *k* itself works within the liner, and is provided with a waist or part *t* of smaller diameter. The working cylinder *d* is provided near its upper end with two ports *u* and *v*, the port *u* acting as an admission port, while the port *v* acts as an exhaust. Four sets of ports *w*, *x*, *y*, *z*—*y* is not shown—are provided in the liner. The ports *w* allow the exhaust air to pass from the space around the waisted or narrow portion *t* of the valve *k* to the exhaust air outlet *p*. The ports *x* allow the exhaust air to pass from the cylinder *d*, through the passage *v*, to the waisted portion *t* of the valve. The ports *y* permit the air to pass from the inlet *o*, through the ports in the valve *k*, to the interior of the valve chamber, from which the compressed air passes through the pipe *h* to the annular space around the tup *f* for the purpose of lifting.—*May 24th*, 1906.

MISCELLANEOUS.

23,857. November 20th, 1905.—IMPROVEMENTS IN THE CONSTRUCTION OF WHEELS FOR TRAMWAY CARS, MOTOR CARS, AND OTHER VEHICLES, William Freakley, of 34, Harding-road, Hanley, and Robert Bill, of Oak Hill, Stoke-on-Trent.

This invention relates to the construction of wheels for use on railway and tramway cars, motor cars, and traction wheels for road rollers, and its principal object is to secure such a degree of resilience as to relieve the central portion of such wheels, together with the axles, axle-boxes, springs, and other connections, from the effects of shocks and vibration. Fig. 2 is a partial section and side view. A disc or body *a* of iron or steel has in the centre a boss or hub for attachment to the shaft or axle. The body *a* is provided with a number of holes *c*, called "cells," of suitable size and form, and passing transversely through the body near its periphery. Into each of such cells is fitted circular or other suitably formed blocks or rings *d* of india-rubber. On each side of the body *a* is arranged a metallic circular side plate, having a central circular hole somewhat larger than the boss or hub *b* of the

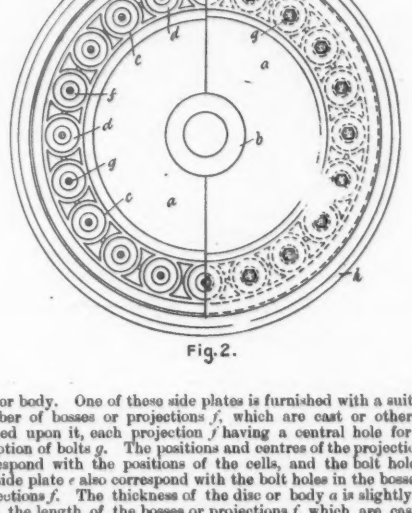


Fig. 2.

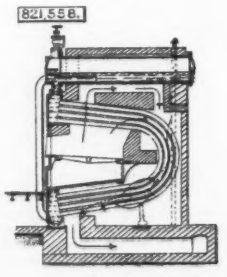
disc or body. One of these side plates is furnished with a suitable number of bosses or projections *f*, which are cast or otherwise formed upon it, each projection *f* having a central hole for the reception of bolts *g*. The positions and centres of the projections *f* correspond with the positions of the cells, and the bolt holes in the side plate *e* also correspond with the bolt holes in the bosses or projections *f*. The thickness of the disc or body *a* is slightly less than the length of the bosses or projections *f*, which are cast or formed on one side of the side plates, when gripped by the bolts *g* passing through and furnished with suitable lock nuts. The degree or extent of such sliding movement is governed by the amount of yield of the rubber rings *d* contained in the "cells." A ring of metal *h* surrounds the side plates, and has an inwardly projecting ring or part *l*, which can be firmly gripped between the side plates by means of bolts passing through holes formed in the several parts. The rim or ring *h* may at once form the tyre, or may act as a seat for a tyre of any suitable form or material.—*May 24th*, 1906.

SELECTED AMERICAN PATENTS.

From the United States Patent-office Official Gazette.

821,558. STEAM BOILER, *H. W. Wagener, Moscow, Russia.—Filed February 27th*, 1906.

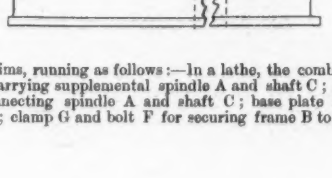
This invention is explained by the drawing. The furnace is



placed inside the group of bent tubes. The flow of the gases is sufficiently indicated by the arrows. There are eight long claims.

821,608. ATTACHMENT FOR INCREASING THE SWING OF LATHES, *A. V. Carroll, Batavia, Ohio.—Filed September 14th*, 1904.

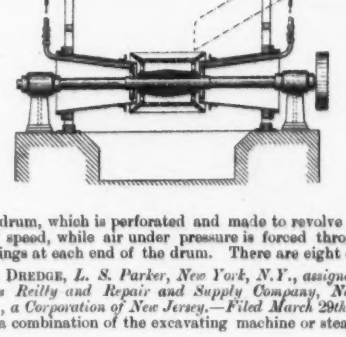
The nature of this invention is clearly set forth in the two last



of five claims, running as follows:—In a lathe, the combination of frame B carrying supplemental spindle A and shaft C; gears *a*, *b* and *c* connecting spindle A and shaft C; base plate D having grooves *d*; clamp G and bolt F for securing frame B to the lathe bed; plate *c'* carrying pins *c²*; and face plate H on the regular live lathe spindle, substantially as specified. A lathe attachment comprising a frame J having a split hub adapted to engage the dead lathe spindle; bolt *j* for securing frame J to said spindle; dead centre piece I carried by frame J; and arm *j'* constructed to have sliding connection with the lathe bed, substantially as specified.

821,609. APPARATUS FOR PULVERISING BLAST FURNACE SLAG, *H. Collosens, Berlin, Germany.—Filed August 14th*, 1905.

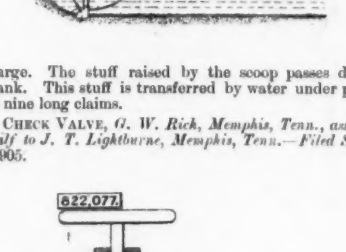
The slag is run into a receptacle, in the bottom of which is



placed a drum, which is perforated and made to revolve at a considerable speed, while air under pressure is forced through perforated rings at each end of the drum. There are eight claims.

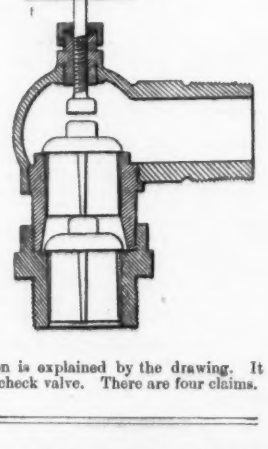
821,670. DREDGE, *L. S. Parker, New York, N.Y., assignor to The James Reilly and Repair and Supply Company, New York, N.Y., a Corporation of New Jersey.—Filed March 29th*, 1906.

This is a combination of the excavating machine or steam navvy



with a barge. The stuff raised by the scoop passes down the hollow shank. This stuff is transferred by water under pressure. There are nine long claims.

822,077. CHECK VALVE, *G. W. Rick, Memphis, Tenn., assignor of one-half to J. T. Lightburne, Memphis, Tenn.—Filed September 5th*, 1905.



This invention is explained by the drawing. It is a compact form of double check valve. There are four claims.

MOTOR LIFEBOAT.—The Royal National Lifeboat Institution have recently directed their attention to the problem of adapting the internal-combustion engine to lifeboats. The latest experiment in this direction has been made by the installation of a Thornycroft four-cylinder 24 horse-power motor in the Newhaven lifeboat Michael Henry, with most satisfactory results. The motor is auxiliary to, and not in place of, the oars usually used, but the boat as now equipped is far more handy than the usual type of lifeboat. The trials were carried out on the Thames under the supervision of Capt. Nepean, the chief inspector of lifeboats, and the average speed attained with the motor only, and with all equipment on board and ballast to the weight of a full crew, was 7·3 knots. In addition to the speed trials, capsizing trials were insisted on and fulfilled, to the complete satisfaction of the National Lifeboat Institution Authorities. These trials were to determine whether the engine casing was perfectly water-tight, and whether the motor would, as required, stop automatically when the boat was keel uppermost. If the propeller continued to revolve when the lifeboat was capsized, it would be liable to injure anyone coming in contact with it, and foul ropes, &c. The boat was completely capsized twice, the motor having previously been started in each case, and each time it stopped automatically when the boat was in an inclined position. The engine casing proved to be absolutely water-tight. The motor started easily, and ran satisfactorily after the capsizing of the boat.

END OF VOL. CI.

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JUL 23 1906

The Engineer.

Registered as a Newspaper

OFFICE FOR ADVERTISEMENTS AND PUBLICATION, 33, NORFOLK STREET, LONDON, W.C.

VOL. CI.—No. 2635] LONDON: FRIDAY EVENING, JUNE 29, 1906. PRICE SIXPENCE

PATENTS, DESIGNS, AND TRADE MARKS ACTS, 1883 TO 1902.

Notice is Hereby Given that

ALFRED PHILLIPS CRABB, of 7, St. Mark's-crescent, Regent's Park, in the County of London, Manufacturer, SEEKS LEAVE to AMEND the SPECIFICATION of Letters Patent No. 26,304 of 1904, granted to him for "Improvements in the Manufacture of Metal Receptacles for Holding Liquid."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 20th June, 1906.

Any person or persons may give notice of opposition to the amendment (on Form G), at the Patent-office, 25, Southampton-buildings, London, W.C., within one calendar month from the date of the said Journal.

C. N. DALTON,
Comptroller-General.

2179

Archbp. Holgate's Grammar

SCHOOL, YORK.

Thorough education in SCIENCE, MATHEMATICS, LANGUAGES, ART, and MANUAL TRAINING. Staff of 16 masters; excellent for boarders; moderate fees; numerous examination results. Curriculum on lines laid down by the Committee of Institute of Engineers (*Nature*, May 10th).—Prospectus on application to the Headmaster, Rev. W. JOHNSON, B.A., B.Sc. (Lond.). 1766

Bedford Grammar School.

ENGINEERING SIDE.

Exhibitions. Head Master's Nominations.—For Syllabus of the Three Years' Course, as approved by the Authorities of the leading London Engineering Colleges, apply, SECRETARY, Grammar School, Bedford. 670

County of London.—The London

County Council invites APPLICATIONS for APPOINTMENT to the POSTS of TEACHER of ENGINEERING and ASSISTANT DEMONSTRATOR in ENGINEERING at the London County Council Paddington Technical Institute, Saltram-crescent, W.

The salary of the Teacher of Engineering will be £150 per annum.

The successful candidate will be required to give lectures and conduct practical classes, day and evening, in Mechanical Engineering. He should have had practical workshop and drawing-office experience, preferably in railway or motor car works, and previous teaching experience is desirable.

The salary of the Assistant Demonstrator in Engineering will be £80 per annum.

The selected candidate will be required to assist in Laboratory, Workshop, and Drawing Office Classes.

The hours of teaching will be arranged to give an opportunity to continue study.

Applicants should have had some practical engineering experience.

Applications should be made on the official form to be obtained from the Clerk of the London County Council, Education Offices, Victoria-embankment, W.C., to whom they must be returned not later than 10 a.m. on Saturday, 7th July, 1906, accompanied by copies of three testimonials of recent date.

Candidates applying through the post for the form of application should enclose a stamped and addressed envelope.

Candidates, other than successful candidates, invited to attend the Committee, will be allowed third-class return railway fare, but no other expenses.

Canvassing, either directly or indirectly, will be considered a disqualification.

G. L. GOMME,
Clerk of the London County Council.

Education Offices,
Victoria Embankment, W.C. 2261

Ministry of Education, Egypt.—

The Egyptian Ministry of Education invites APPLICATIONS for POST of INSTRUCTOR in MECHANICAL ENGINEERING, at Khedivial Technical School, Cairo.

Salary £430 per annum (£Eg. 35 per mensem), rising to £553 per annum (£Eg. 45 per mensem).

Allowance for passage out to Egypt.

Applicants must be not less than 25 years nor over 30 years of age.

They must be thoroughly practical, competent to take charge of mechanical engineering works, and to conduct lectures and classes.

They must have had a complete training in the mechanical workshops and drawing-offices of some recognised firm of engineers, and must also have obtained a diploma in engineering from a University or recognised Technical College.

Applications, with a copy of testimonials, must be posted not later than June 27th, 1906, to R. HOLT, Esq., School of Engineering, Giseh, Egypt, from whom further information may be obtained by letter.

Applications and correspondence posted after the above-mentioned date up till July 21st, 1906, must be addressed to R. HOLT, Esq., care of Sir Benjamin Baker, G.C.M.G., 2, Queen-square-place, Queen Anne's-mansions, Westminster, S.W.

Selected candidate required to begin work in October. 1923

THE VICTORIA

University of Manchester.—The

Council is about to APPOINT to a VULCAN FELLOWSHIP in MECHANICAL and ELECTRICAL ENGINEERING, which is open to University Graduates only. Value £120.

The detailed conditions of the appointment may be obtained from the REGISTRAR. 2206

Blackbrook Masonry Dam.—The

Corporation of Loughborough, in consequence of the near completion of this work, invite INSPECTION and OFFERS for PLANT used in its construction, comprising:—

1. Five-ton Steam Power SCOTCH DERRICK CRANE, with steel lattice-framed jib 90ft. long, built by J. M. Henderson and Co., Aberdeen.
2. Five-Ton Steam Power DERRICK CRANE, by Jessop, Appleby and Co., of Leicester, with 80ft. steel lattice jib and portable hand travelling gear.
3. Four-ton Timber-framed Steam Power DERRICK CRANE, with jib 48ft. long, by Booth, Leeds.
4. Five-ton Steam Power SCOTCH DERRICK CRANE, with timber jib 48ft. long, by William Morgan, Kilwinning.
5. Five-ton Steam Navvy LOCOMOTIVE CRANE, with spare steel lattice jib 30ft. long, by Whittaker Bros., Leeds.
6. Four-ton Steam LOCOMOTIVE CRANE, by Butters Bros., Glasgow, with steel lattice jib 30ft. long.

Nos. 1, 2, and 4 can be loaded on rails immediately.
Nos. 2, 5, and 6 will complete their work in five or six weeks.
Application to inspect to be made to
GEORGE and F. W. HODSON, MM. Inst. C.E., Engineers.

Loughborough, 2nd June, 1906. 2186

City of Leeds.—Waterworks.

NEW FILTER BEDS.
HEADINGLEY.

The Waterworks Committee invite TENDERS for the CONSTRUCTION of FOUR FILTER BEDS, CLEAR WATER TANK, METER HOUSE, the MAKING of ROADS, LAYING of PIPES and DRAINS, &c., in connection therewith, at the site of their New Filter Beds, Otley-road, Headingley, Leeds.

Plans may be seen, and the specification, bill of quantities, and form of Tender obtained at the office of Chas. G. Hensell, M. Inst. C.E., Waterworks Engineer, Municipal Buildings, Leeds, on payment of a deposit of £5, which will be returned on receipt of a bonâ fide Tender, accompanied by the documents received, and which Tender shall not have been withdrawn.

Tenders, endorsed "Tender for New Filter Beds, &c., at Headingley," must be addressed to the Chairman of the Waterworks Committee, and delivered in a sealed cover at the Town Clerk's Office, Town Hall, Leeds, not later than 10 a.m. on the 20th July, 1906.

The lowest or any Tender not necessarily accepted.

ROBERT E. FOX,
Town Clerk.

Town Hall, Leeds,
June 25th, 1906. 2197

City of Birmingham.—Water

DEPARTMENT.
FILTERED WATER RESERVOIR, &c., FRANKLEY.

The Corporation of Birmingham are prepared to receive TENDERS from competent persons willing to enter into a Contract for the CONSTRUCTION of a COVERED FILTERED WATER RESERVOIR and CONNECTIONS at the Frankley Waterworks, Northfield, near Birmingham.

The drawings may be seen, and specification and bills of quantities obtained, at these offices on and after July 2nd next, on the deposit of the sum of £5, which will be returned after the receipt of a bonâ fide Tender, with the bills of quantities fully priced out.

The site at Frankley may be inspected by appointment from July 2nd to July 6th inclusive.

Early application for particulars is necessary, as only a limited number will be given out, and none after July 6th.

The contractor will be required to undertake not to pay less than the minimum standard rate of wages current in the district in which the works are situate.

Sealed Tenders, addressed to me and endorsed "Tender for Works at Frankley," are to be delivered at these offices at or before noon of Friday, July 20th, 1906.

The Corporation do not bind themselves to accept the lowest or any Tender.

(Signed) E. ANTONY [illegible], Secretary.

Offices, 44, Broad-street, Birmingham,
21st June, 1906. 2077

County Borough of Bolton.—

ELECTRICITY DEPARTMENT.

The Electricity Committee of the Bolton Corporation invite TENDERS for the SUPPLY, DELIVERY, and ERECTION of CONDENSING APPARATUS.

Specification and form of Tender may be had on application to Mr. Arthur A. Day, A.M.I.C.E., M.I.E.E., Borough Electrical Engineer and Tramways General Manager, Spa-road, Bolton, on and after 23rd June instant.

Tenders, endorsed "Condensing Apparatus," to be addressed to the Chairman of the Electricity Committee, Town Clerk's Office, Town Hall, Bolton, and must be delivered not later than 12 o'clock noon on July 12th, 1906.

The Committee do not bind themselves to accept the lowest or any Tender.

SAMUEL PARKER,
Town Clerk.

Town Hall, Bolton.
16th June, 1906. 2071

County of London.—To Con-

TRACTORS AND OTHERS.

The London County Council invites TENDERS for the CLEANING, RE-PAINTING, &c., of LEA BRIDGE, CLAPTON.

Persons desiring to submit Tenders may obtain the specification, bills of quantities, form of Tender, and other particulars on application to the Chief Engineer, Mr. Maurice Fitz-Maurice, C.M.G., at the County Hall, Spring-gardens, S.W., upon payment to the Cashier of the Council of the sum of £1.

This amount will, after the Council or its Committee shall have come to a decision upon the Tenders received, but not before, be returned to the tenderer, provided he shall have sent in a bonâ fide Tender, and not have withdrawn the same, but in no case will the fee be returned unless a bonâ fide Tender is submitted.

Full particulars may be obtained on application at the County Hall, previously to the payment of the fee for the specification, &c.

Tenders must be upon the official forms, and the printed instructions contained therein must be strictly complied with.

The contractors will be bound by the contract to pay all workmen (except a reasonable number of legally bound apprentices) employed by them wages at rates not less, and to observe hours of labour not greater, than the rates and hours set out in the Council's list, and such rates of wages and hours of labour will be inserted in, and form part of, the contract by way of schedule.

Each Tender is to be delivered at the County Hall in a sealed cover, addressed to "The Clerk of the London County Council, Spring-gardens, S.W.," and marked "Tender for Painting, &c., Lea Bridge."

No Tender will be received after 10 a.m. on Tuesday, the 10th July, 1906.

Any Tender which does not comply with the printed instructions for Tender may be rejected.

The Council does not bind itself to accept the lowest or any Tender, and it will not accept the Tender of any person or firm who shall on any previous occasion have withdrawn a Tender after the same had been opened, unless the reasons for the withdrawal were satisfactory to the Council.

G. L. GOMME,
Clerk of the London County Council.

County Hall, Spring-gardens, S.W.,
22nd June, 1906. 2195

County Council of Middlesex.

TO CONTRACTORS.

The Light Railways and Tramways Committee of the County Council invite TENDERS for the WORK and MATERIALS REQUIRED in the CONSTRUCTION of the PERMANENT WAY (for Electric Traction), BRIDGE WORK, ROAD WIDENINGS, &c., for

CONTRACT No. 17.

Railway No. 1 (Order 1903).—A line of double track (with cross-overs, contingent works, &c.), to be laid along Green Lanes, in the districts of Wood Green and Southgate, in the county of Middlesex, to a length of 3 miles 0 furlongs 4 chains, or thereabouts.

The plans, conditions of contract, specification of works, &c., for this contract may be seen, and schedules of quantities obtained, by intending contractors (on payment of £10, which will be returned on receipt of a bonâ fide Tender) on application at my offices, between office hours, on and after Wednesday, June 27th, 1906.

Tenders, properly sealed and endorsed "Tender for Light Railway No. 1," to be delivered to Sir Richard Nicholson, Clerk of the County Council, Middlesex Guildhall, Westminster, S.W., not later than 12 noon on Wednesday, July 11th, 1906.

The County Council does not bind itself to accept the lowest or any Tender.

H. T. WAKELAM, M. Inst. C.E.,
County Engineer.

Middlesex Guildhall,
Westminster, S.W.,
14th June, 1906. 2154

STEEL PIPES.

Derwent Valley Water Board.

DERWENT AQUEDUCT.

The Derwent Valley Water Board is prepared to receive TENDERS for the MANUFACTURE and SUPPLY of STEEL PIPES for a section of the above work.

There will be about 400 yards of 40in. Steel Pipes; 4000 yards of 32in. ditto; and 1250 yards of 29in. ditto.

Particulars may be obtained on application to Mr. Edward Sandeman, M.I.C.E., Engineer to the Board, at these Offices, on payment of Two Guineas, which will be returned on receipt of a bonâ fide Tender and the documents furnished by him.

Sealed Tenders, endorsed "Tender for Steel Pipes," to be delivered to him not later than 9 o'clock on Tuesday morning, the 3rd July.

The Board will not be bound to accept the lowest or any Tender.

O. B. STEWARD,
Clerk to the Board.

Bamford, near Sheffield,
21st June, 1906. 2187

Great Northern Railway Com-

PANY (IRELAND).

The Directors are prepared to receive TENDERS for the PURCHASE of about 1600 TONS of OLD STEEL RAILS (Flange, Double-head and Bull-head Sections).

Forms of Tender may be obtained on application to the Secretary.

Tenders, made out on the proper form, and marked "Tender for Old Rails," must be lodged with the undersigned not later than 10 a.m. on Monday, 9th July, 1906.

The Directors do not bind themselves to accept the highest or any Tender.

T. MORRISON,
Secretary.

Secretary's Office,
Amiens-street Terminus,
Dublin, 27th June, 1906. 2230

Lancashire Asylums Board.

COUNTY ASYLUM, RAINHILL.
PUMPING ENGINES FOR SALE.

The Committee of Visitors are prepared to receive PRICES for TWO 12in. HORIZONTAL PUMPING ENGINES, 6in. pumps, 16in. stroke, double-acting.

Can be seen at the Pumping Station of the County Asylum, Rainhill. Makers, Mather and Platt.

Prices to include taking down and removing from site.

Tenders to reach my office not later than 5 p.m. on Thursday, July 26th, endorsed on the outside "Pumps."

The Committee do not bind themselves to accept the highest or any Tender.

By order,
JAS. GORNALL,
Clerk and Steward.

Clerk's Office, County Asylum, Rainhill,
June 25th, 1906. 2213

Metropolitan Water Board.

TENDERS FOR SLUICE VALVES.
FORTIS GREEN RESERVOIRS.

The Metropolitan Water Board invite TENDERS for the MAKING, TESTING, and DELIVERING of 42in. and other SLUICE VALVES, &c.

Forms of Tender and contract with specification may be obtained, and the drawings inspected, upon application to the Engineer at the Firs, Southern-road, Fortis Green, East Finchley, on or after Friday, the 29th June, 1906, between the hours of 10 and 4 (except on Saturdays).

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board, Metropolitan Water Board, Savoy-court, Strand, W.C., and endorsed "Tender for Sluice Valves, &c., Fortis Green Reservoirs," must be delivered at the offices of the Board not later than 10 a.m. on Tuesday, the 10th July, 1906.

The Board do not bind themselves to accept the lowest or any Tender.

Savoy-court, Strand, W.C.,
27th June, 1906. 2219

Metropolitan Water Board.

TENDERS FOR PIPE-LAYING.

The Metropolitan Water Board invite TENDERS for the LAYING of about 3000 YARDS of WATER MAIN, from Plumstead Common to Woolwich Common Reservoir, in the Kent District.

Forms of Tender, with schedule and conditions of contract, may be obtained on application to the District Engineer, at the Board's Offices, Brookmill-road, Deptford, S.E.

Such application must be made between the hours of 10 and 4 (except on Saturdays) on and after Friday, 29th June, 1906.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board, and endorsed "Tender for Pipe-laying, Kent District," must be delivered at the offices of the Board not later than 10 a.m. on Tuesday, 10th July, 1906.

The Board do not bind themselves to accept the lowest or any Tender.

Savoy-court, Strand, W.C.,
26th June, 1906. 2221

Metropolitan Water Board.

TENDERS FOR SLUICE VALVES.
AQUEDUCT, CHILD'S HILL TO CRANLEY GARDENS.

The Metropolitan Water Board invite TENDERS for the MAKING, TESTING, and DELIVERING of 42in. and other SLUICE VALVES, &c.

Forms of Tender and contract, with specification, may be obtained, and the drawings inspected, upon application to the Engineer, at the Firs, Southern-road, Fortis Green, East Finchley, on or after Friday, the 29th June, 1906, between the hours of 10 and 4 (except on Saturdays).

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board, Metropolitan Water Board, Savoy-court, Strand, W.C., and endorsed "Tender for Sluice Valves, &c., Aqueduct, Child's Hill to Cranley Gardens," must be delivered at the offices of the Board not later than 10 a.m. on Tuesday, the 10th July, 1906.

The Board do not bind themselves to accept the lowest or any Tender.

Savoy-court, Strand, W.C.,
27th June, 1906. 2220

North-Eastern Railway.—The

Directors are prepared to receive TENDERS for the RENEWAL of the SUPERSTRUCTURE of the BRIDGE carrying the passenger lines over the River Tees near Thornaby, Stockton, and the CONSTRUCTION and ERECTION of a NEW STEEL BRIDGE, of five spans, of a total length of about 340ft., including about 360 tons of steel work. The contract will also include the Removal and Rebuilding of part of the Piers in Masonry. Plans may be seen, and specification, detailed quantities, and form of Tender obtained, on personal application at the office of Mr. W. J. Cudworth, the Company's Engineer, at York, on and after Monday, the 25th June. Sealed Tenders, marked "Tenders for the Renewal of Tees Bridge, Thornaby," must be sent to the Secretary, at York, before noon on Tuesday, July 24th. The Directors do not bind themselves to accept the lowest or any Tender.—R. F. DUNNELL, Secretary, York, 21st June, 1906. 2178

Royal Siamese State Railways.

TENDERS are requested for an IRON BRIDGE across the Menam River, Siam.

Drawings and conditions may be obtained for a payment of 10s. from W. A. Evans, Acting Financial Agent, Siamese Legation, 23, Ashburn-place, S.W.

Sealed Tenders must be forwarded to the undersigned, in whose office they will be publicly opened on October 1st, 1906.

L. WEILER,
Director-General Railway Department,
Bangkok, Siam. 2272

Southport, Birkdale, and West

LANCASHIRE WATER BOARD.
TO PIPE FOUNDERS.

The Board are prepared to receive TENDERS for the MANUFACTURE and DELIVERY of about 370 TONS of CAST IRON PIPES and SPECIAL CASTINGS.

A copy of the specification and form of Tender can be obtained at the offices of Messrs. H. Rofe and Son, 8, Victoria-street, Westminster, on and after Monday, the 2nd of July, on payment of Five Guineas, to be returned upon receipt of a bonâ fide Tender.

Tenders to be sent in to the undersigned on or before Ten o'clock in the forenoon of Thursday, the 12th July next, endorsed "Tender for Pipes."

The Board do not bind themselves to accept the lowest or any Tender.

ALLEYNE BROOK,
Clerk to the Board.

11, St. George's-place,
Lord-street, Southport,
June, 1906. 2201

Twickenham Urban District

COUNCIL.
SEWAGE DISPOSAL AND REFUSE DESTRUCTOR WORKS.
CONTRACT "G."—ELECTRIC LIGHTING, &c

The above Council invite TENDERS for the ELECTRIC LIGHTING and SUPPLY of ELECTRICAL MACHINERY, &c., at the Pumping Station and Destructor Buildings, Sewage Disposal Works, The Mereway, Twickenham.

Specifications and forms of Tender may be obtained, and drawings inspected, at the office of Mr. William Fairley, Consulting Engineer to the Council, 59, Victoria-street, Westminster; also on application to Mr. Fred. W. Pearce, Surveyor to the Council, Town Hall, Twickenham, on deposit of crossed cheque for Two Guineas, made payable to the Council, which deposit will be returned on receipt of a bonâ fide Tender.

Sealed Tenders, on the forms supplied by the Council, to be delivered to the undersigned on or before noon on Wednesday, the 11th day of July, 1906.

The Council do not bind themselves to accept the lowest or any Tender.

By order,
H. JASON SAUNDERS,
Clerk to the Council.

20th June, 1906.
Town Hall Twickenham. 2175

Bombay, Baroda, and Central

INDIA RAILWAY.
ASSISTANT TELEGRAPH SUPERINTENDENT.

The Directors are prepared to receive APPLICATIONS (by letter only) from duly qualified candidates, for APPOINTMENT as an ASSISTANT TELEGRAPH SUPERINTENDENT in the Company's Service in India.

Candidates should not be under 25 or over 30 years of age, and must have had a technical education at some recognised engineering college, and must possess a thorough knowledge of railway electrical appliances for train signalling and electrical interlocking of signals, the manufacture of electrical instruments, testing of telegraph lines, and the management of dynamos and charging of storage cells.

Salary, Rs. 350, rising on approved service to Rs. 500 per calendar month.

Terms:—A 5 years' agreement, with first-class free passage to India, and home again on termination of service, unless forfeited by misconduct.

The candidate selected will be required to pass a medical examination by the Company's Consulting Physician before appointment.

Letters of application, accompanied by a brief record of the candidate's career, with copies of testimonials (not originals), marked outside "Assistant Telegraph Superintendent," should be addressed to the undersigned not later than the 11th July.

W. V. CONSTABLE,
Officiating Secretary.

Offices, Gloucester House,
Bishopsgate-street Without,
London, E.C., 27th June, 1906. 2269

County of London.—The London

County Council invites APPLICATIONS for the APPOINTMENT of a PRINCIPAL ELECTRICAL ASSISTANT in the Engineer's Department.

Candidates must be between 30 and 45 years of age, and should be students, associates, or members of the Institute of Electrical Engineers.

They should have had experience both in the design and construction of electrical machinery, and should have good knowledge of electric lighting and wiring.

Preference will be given to a candidate who has proved himself capable of organising and taking charge of a considerable staff.

The salary attached to the appointment will be £500 a year, and the gentleman appointed will hold his office during the pleasure of the Council, will be required to give his whole time to the duties of his office, and will not be allowed to take any private practice, to hold any other appointment, or to occupy any other paid position, and any fees received by him either as a witness or in any other capacity are to be paid to the Council; and he will further be required to conform to the Council's regulations in respect of the superannuation and provident fund, in the benefits of which he will participate.

Forms of application can be obtained either by applying personally or by sending a stamped addressed foolscap envelope to the "Clerk of the Council, County Hall, Spring-gardens, S.W.," and the latest time for receiving applications is 10 a.m. on Friday, 13th July, 1906.

Personal canvassing of members of the Council is strictly prohibited.

G. L. GOMME,
Clerk of the London County Council.

County Hall,
Spring-gardens, S.W.,
27th June, 1906. 2240

Singapore, Straits Settlement.

MUNICIPAL ENGINEER'S DEPARTMENT.

The Municipal Commissioners of the Town of Singapore REQUIRE, as soon as possible, an ASSISTANT ENGINEER, between 23 and 35 years of age, of sound constitution. He must have had a good technical education, a regular training as a civil engineer, experience in surveys, and in plans for and in the construction of all kinds of roads. Preference would be given to a candidate with experience in the plant and in the preparation of materials used in road-making, including quarrying, also to one connected with the Institution of Civil Engineers.

The engagement will be for three years, and the applicant is to state the earliest date upon which he would be prepared to leave for Singapore.

A second-class passage will be provided by mail steamer, or first-class passage by other steamer, with half pay during the voyage out.

The salary will be dollars 3600 for the first, 3900 for the second, and 4200 for the third year, paid monthly at a fixed dollar rate of two shillings and fourpence sterling, with such local transport allowance as may, from time to time, be sanctioned by the Commissioners.

Applications, stating age and place of birth, and giving details of education, training and experience generally, and particularly in municipal work, and referring to the above qualifications seriatim, accompanied by copies (only) of testimonials and personal references, to be lodged with C. C. Lidbury, Esq., M. Inst. C.E., 180, Hope-street, Glasgow (who will give further particulars if requested), not later than Tuesday, 10th July, 1906. 2231

Wanted, Assistant to Managing

Director of a Constructional Steel Works: must be between 30 and 40 years of age, with a sound engineering training, and have had considerable experience in dealing with correspondence and complicated matters connected with bridge work and general engineering; must be able to write shorthand, also to dictate letters and attend to correspondence; good salary would be paid to an efficient man.—Reply, in confidence, giving full particulars of past experience and salary expected, to Box 632, c.o. Messrs. R. F. White and Son, General Advertising Agents, 33, Fleet-street, E.C. 2253

Wanted, Engineer, Six o'Clock

man, for works; must be well experienced in Electric Generating Plant, &c., also in High-speed and other Steam Engines; used to economical control of men.—Address, stating age, experience, and salary required, 2211, Engineer Office, 33 Norfolk-street, Strand, W.C. 2211

Wanted, First-class Assistant

EXPERT and DRAUGHTSMAN in Gas Engines, Suction Gas Plants and Oil Engines. Must be thoroughly practical engineer, good designer, and well up in theory and the most modern practice.—Apply, stating age, full particulars of experience, and salary required, to DAVEY, PAXMAN and CO., Ltd., Engineers, Colchester. 2167

Wanted, Geologist or Mining

ENGINEER, young, with thorough knowledge of the geology of iron ore, especially hematite, to proceed abroad, and advise on iron ore deposits. Six or twelve months' engagement. Fluent French essential. — Address, stating age, qualifications, experience, reference, and salary, to 2069, Engineer Office, 33, Norfolk-street, Strand, W.C. 2069

Wanted, Works Manager for a

small General Engineering Works in London. Motor and all kinds of repair work a specialité. Applicants to state age, experience, and salary required, &c.—Address, 2204, Engineer Office, 33, Norfolk-street, Strand, W.C. 2204

SMALL ADVERTISEMENTS.

SITUATIONS, FOR SALE, &c.

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Assistant Wanted for Indian Branch of Iron Roofing and Bridge Manufacturers. Must have thorough knowledge of such work; age 25 to 30, unmarried; five years' agreement; salary starting £250, with £50 yearly advance.—Address, 2193, Engineer Office, 33, Norfolk-street, Strand, W.C. 2193

Civil Engineer for the Far East; experienced in Earth, Masonry Work, and general Building Construction; single man, 30 to 36, with Oriental experience preferred; salary £350 to start with, and commission.—Address full particulars to Z. C. E., c.o. Messrs. Deacon's, Leadenhall-street, E.C. 2255

Civil Engineer Required, and to Assist in Engineering Department. Must have a thorough theoretical and mathematical training, with experience in designing and carrying out all kinds of structural work.—Write, stating age, full particulars of experiences, and commencing salary required to 1008, c.o. Brown's, 17, Tothill-street, Westminster. P369

De Beers Consolidated Mines, KIMBERLEY.—WANTED, first-class MECHANICAL and ELECTRICAL ENGINEER as ASSISTANT GENERAL MANAGER. Age 35 to 43. Salary £1800 and free quarters. Must have considerable experience and high technical qualification.—Apply in writing, enclosing copies of testimonials, to A. SMART, 15, St. Swithin's-lane, London, E.C. 2270

Foundry Manager. — Practical FOUNDRY MANAGER REQUIRED. Good metallurgist. Experience in latest machine and other moulding methods. Knowledge of steel or malleable ironwork an advantage. State age, experience, and salary required.—Address, 2200 Engineer Office, 33, Norfolk-street, Strand, W.C. 2200

Kynoch Limited Require the SERVICES of an ELECTRICAL ENGINEER, unmarried, and not over 30, for work in South America. Must have had commercial and thorough technical experience. Man already acquainted with South America preferred.—Apply by letter only, with full particulars of past experience, age, and salary required, to SECRETARY, Kynoch Limited, Lion Works, Witton, near Birmingham. 2248

Mechanical Engineer Wanted to Take Charge of Engineering Department on large producing mine abroad. Must have had experience in similar position.—Apply by letter, giving age and full particulars of qualifications and experience, to T. C. W., care of Street's, 30, Cornhill, E.C. 2215

Required, as Assistant to the BLAST-FURNACE MANAGER, a Young Engineer, who must have had a first-class training, both technical and practical, and preferably a year or two practical experience of blast-furnace work.—Apply, stating age and all particulars of education, training, and subsequent work, together with ideas of salary expected, to the GENERAL MANAGER, Ebbw Vale Steel, Iron, and Coal Co., Ltd., Ebbw Vale, Mon. 2067

To Engineers.—Wanted, Married MAN as ASSISTANT in a small Engineer's and Contractor's Business in South of England. Must be energetic, good draughtsman and estimator; able to control men. State age, wages, and experience, and when disengaged, and copies of testimonials, not returnable. This is a permanency for suitable man.—Address, 2133, Engineer Office, 33, Norfolk-street, Strand, W.C. 2133

Wanted, a First-class Draughts- MAN for constructional steel work; a knowledge of gasholder work a recommendation, but not essential.—Apply, giving full particulars, stating age and salary required, to 2242, Engineer Office, 33, Norfolk-street, Strand, W.C. 2242

Wanted, Draughtsman, Accus- TOMED to Small Marine Work.—Reply, with full particulars, to CRABTREE and CO., Ltd., Engineers, Great Yarmouth. 2214

Wanted, Experienced Draughts- MAN; one who is thoroughly conversant with the designing of Railway Carriage Underframes, Brake Rigging &c.; railway man preferred.—Write, stating age, with full particulars of experience and salary required, to X. Y. Z., c.o. Smith's Advertising Offices, 51, Moorgate-street, E.C. 2250

Wanted, First-class Draughts- MAN, accustomed to Electric Cranes and Travellers (none other need apply). State references and salary expected. —JESSOP and APPLEBY BROS. (Leicester and London), Limited, Leicester. 2210

Wanted, First-class Head DRAUGHTSMAN for Machine Tool Works in Halifax. Good salary.—Address, in confidence, 2271, Engineer Office, 33, Norfolk-street, Strand, W.C. 2271

Wanted for Ironworks in the Midlands, handy DRAUGHTSMAN, able to make working drawings of rolling mill and similar heavy machinery from sketches and superintend erection. Must have some knowledge of calculations and patternmaking. — Address, stating experience, age, and wages required, to P330, Engineer Office, 33, Norfolk-street, Strand, W.C. P330

Wanted, Thoroughly Experi- ENCED DRAUGHTSMAN, capable of taking out quantities and cost mates. Give references and experience.—R. H. LONGBOTHAM and CO., Ltd., Ings Foundry, Wakefield. 2235

Draughtsman (Good Mechanical), not under 25 years.—Particulars regarding experience and salary to VAUGHAN and SON, Limited, Overhead Electric Travelling Crane Manufacturers, West Gorton, Manchester. 2236

Draughtsman Required, having good knowledge and experience in Patent Drawings. State fullest particulars, salary expected (moderate).—Address, P343, Engineer Office, 33, Norfolk-street, Strand, W.C. P343

Draughtsman Required, with long experience in Electrical Engineering, used to dealing with large units, both continuous and alternating.—Address, stating age, qualifications, salary, &c., 2181, Engineer Office, 33, Norfolk-street, Strand, W.C. 2181

Draughtsman.—Wanted, a Com- PETENT DRAUGHTSMAN, by a large Firm of Manufacturers in the South-west district; age 20 to 25.—Write, stating age, experience, and salary required, to 2237, Engineer Office, 33, Norfolk-street, Strand, W.C. 2237

Draughtsman Wanted by Firm of Constructional Engineers and Bridge Builders; must have experience in Designing and Quantities for Estimating.—State age, experience, terms, &c., to 2208, Engineer Office, 33, Norfolk-street, Strand, W.C. 2208

Draughtsman Wanted in Light Constructional Steelworks, well up in Designs and Stresses; age 28 or over.—Write fully, stating age, experience, and when free, REES and KIRBY, Ltd., Morriston, Swansea. 2251

Draughtsman Wanted, with good experience in Marine Petrol Engines; permanency; good prospects for capable man; this is not a junior position, and none but thoroughly competent men need apply. State age, experience, and salary expected to 2207, Engineer Office, 33, Norfolk-street, Strand, W.C. 2207

Draughtsman (21-25), who has served time in shops, for General Drawing, Tracing, &c. College training also preferred. Salary, £100-£150 p.a., according to experience and qualifications, which should be given in full.—Address, P303, Engineer Office, 33, Norfolk-street, Strand, W.C. P303

Experienced Assistant Draughts- MAN for Railway Rolling Stock WANTED.—Address, stating age, experience, salary required, and references, 2183, Engineer Office, 33, Norfolk-street, Strand, W.C. 2183

First-class Draughtsman, Accus- TOMED to Conveying and Hoisting Machinery for Engineering Works in London.—Apply (by letter only), stating age, experience, and salary required, to Box 650, care of Messrs. R. F. White and Son, General Advertising Agents, 33, Fleet-street, E.C. 2222

First-class Draughtsman, having special knowledge of and experience with Motor Car work, WANTED in London district; good opportunity for capable man. — Write, giving full particulars of experience, stating age and salary required, to G. S. L., c.o. Street's, 30, Cornhill, E.C. 2263

Head Draughtsman.—Wanted, First-class MAN for large Engine Works in the Midlands. Must have good experience in high-class work, and be capable of taking full charge of and organising drawing-office staff for a works employing over 2000 men. Liberal salary will be paid to suitable man. Replies, which will be treated in strict confidence, must state age, particulars of experience, and salary required.—Address, 2182, Engineer Office, 33, Norfolk-street, Strand, W.C. 2182

Junior Draughtsman Wanted for Jig and Tool Drawing-office; must have had workshop experience. — Apply, stating age, experience, and salary required, to Messrs. ALFRED HERBERT, Ltd., Works Office, Coventry. 2184

Required, a Young Mechanical DRAUGHTSMAN; must be well educated, had good theoretical and practical training.—Apply by letter, stating age, experience, and salary expected, to MECHANICAL, c.o Abbott's, 32, Eastcheap, London, E.C. P349

Wanted Immediately, a First- CLASS MACHINE SHOP FOREMAN; must be thoroughly accustomed to the use of up-to-date machines, and to the repairs to machinery in iron and steel rolling mills; none but men accustomed to high-speed machinery, good organisers and timekeepers, need apply.—State previous experience and salary required to 2189, Engineer Office, 33, Norfolk-street, Strand, W.C. 2189

Wanted Immediately, a First- CLASS STEEL WORKS MECHANICAL FOREMAN; must be thoroughly accustomed to the Engineering Work in large Plate and Section Mills; none but thoroughly well-trained men, good organisers and timekeepers, need apply. —Address, 2188, Engineer Office, 33, Norfolk-street, Strand, W.C. 2188

Engineer Wanted to Take Posi- TION of UNDER-FOREMAN or LEADING HAND in OIL ENGINE DEPARTMENT of large Engineering Works, London district; must have had practical experience in similar works, energetic, and good disciplinarian; wages £2 2s. per week to start.—Apply by letter to OIL, c.o. Bates, Hendy and Co., 4, Budge-row, Cannon-street. 2224

Head Toolmaker Wanted for REPETITION WORK; must have thorough knowledge of best machine shop practice and ability to control men.—Apply, with full particulars, including age, experience, and salary required, to P348, Engineer Office, 33, Norfolk-street, Strand, W.C. P348

Agent Wanted for the Sale of FERRO-TUNGSTEN and WOLFRAM METAL IN THE SHEFFIELD DISTRICT. Please address, stating qualifications, G. H. 317, care of Rudolf Mosse, Leipzigerstr. 103, Berlin. 2254

Wanted by Sheffield Steel Manufacturers, GENTLEMAN calling upon Tin-plate Works, Iron and Steel Works, Engineers, Collieries, &c., to PUSH their SPECIALITIES of High-speed Steel, Twist Drills, and Shear Blades on commission in South Wales and Monmouthshire. Preference given to applicant with a knowledge of the trade.—Reply to Box 59, General Post-office, Sheffield. 2191

Engineers' Tools, Milling Cutters, GAUGES, &c.—A GOOD TRAVELLER or COMMERCIAL MAN REQUIRED; energetic; good knowledge of users' requirements, prices, catalogues, &c.; state age, experience and salary.—Address, 2199, Engineer Office, 33, Norfolk-street, Strand, W.C. 2199

Representative, Yorkshire and N.E. Coast. Must have connection with engineers, steel manufacturers, and allied trade; practical mechanic preferred; answers must state experience, salary required, giving references; confidential. — Address, 2192, Engineer Office, 33, Norfolk-street, Strand, W.C. 2192

Traveller Required; Must be man of good calibre, able to deal with inquiries and hunt up new business; must be energetic and able to hold his own in transacting business; some mechanical experience is necessary. — Address, 2225, Engineer Office, 33, Norfolk-street, Strand, W.C. 2225

Traveller Wanted with Good connection amongst Advertisers of Engineering Goods. —Address, 197, Sell's Advertising Offices, London, E.C. 2262

Wanted, a Smart Boilermaker for the East. Must have a good all-round experience, and used to repair work; age about 30.—For further particulars, write Z. B. M., care of Deacons, Leadenhall-street, E.C. 2274

Wanted, for Large Engineering Works, SIX good MACHINISTS, used to Vertical Lathes, Horizontal Boring Machines, and Side Planers.—Write, stating age, experience, and wages required, to 2234, Engineer Office, 33, Norfolk-street, Strand, W.C. 2234

Wanted, North London, a First- CLASS TURNER, also PLANER, and a MILLING MACHINE HAND. Only those used to good and accurate work need apply, stating experience and shops worked in. Address, P373, Engineer Office, 33, Norfolk-street, Strand, W.C. P373

Wanted, Smart Youth for Tool LATHE; one who has had some experience in technical school preferred.—Address, 2196, Engineer Office, 33, Norfolk-street, Strand, W.C. 2196

High-speed Engine Fitters WANTED, on Motor Omnibus-Repair Works.—First-class men, of best experience only, need apply, by letter only, to ENGINEER, Thomas Tilling, Ltd., Bull-yard, High-street, Peckham, S.E. 2209

As Assistant Civil Engineer.— Graduate of Cambridge, with honours in the Mechanical Science Tripos, SEEKS an APPOINTMENT.—Address, P332, Engineer Office, 33, Norfolk-street, Strand, W.C. P332

Civil Engineer (27) Wants Post with Engineer or Contractor; home or abroad; 6 years' experience harbour, sewage, drainage, bridge work; graduate; good mineralogist; very moderate salary.—Address, P355, Engineer Office, 33, Norfolk-street, Strand, W.C. P355

Engineer, Late R.N., A.M. Inst. C.E., at present General Manager of Engineering Works, WISHES APPOINTMENT as REPRESENTATIVE to first-class firm, or ASSISTANT to agent or consultant with large connection. Intimate with modern marine, general, electrical, and colliery engineering practice and business, including steel manufacture and constructional work. Age 31, good appearance and address, with first-class references as to technical and commercial ability.—Address, P338, Engineer Office, 33, Norfolk-street, Strand, W.C. P338

Engineer, 5—6 Years' Works experience, thorough theoretical training, expert calculator and designer, DESIRES POSITION as ASSISTANT DESIGNER or WORKS MANAGER.—Address, P326, Engineer Office, 33, Norfolk-street, Strand, W.C. P326

Engineer (27) Desires Position as ASSISTANT MANAGER or FOREMAN; 11 years' experience on traction, portable, marine, and gas engines and tools. Had charge of works for last four years. Good testimonials.—Address, P344, Engineer Office, 33, Norfolk-street, Strand, W.C. P344

Engineer (33) Desires Position, preferably abroad. Eight years' superintendent in charge of fleet of small craft, &c. General experience in designing, building, running, and repairing light craft and general machinery. Accustomed to full charge of large number of workmen, and has also considerable commercial experience. Health always excellent (including nine years in tropics). First-class references, including personal ones in London.—Address, F. E., care Davies and Co., Advertising Agents, Finch-lane, Cornhill. 2249

Engineer (35), with 15 Years' Railway experience, holding responsible position, well up in bridgework, strains, &c., energetic, SEEKS APPOINTMENT; moderate salary; highest references.—Address, P333, Engineer Office, 33, Norfolk-street, Strand, W.C. P333

Engineer (37), Ten Years as foreman and manager with modern firm, REQUIRES a RESPONSIBLE SITUATION; exp. general engineering, repetition, and tool-room work; first-class refs.—Address, P361, Engineer Office, 33, Norfolk-street, Strand, W.C. P361

Gentleman, Just Resigned Ap- POINTMENT as WORKS MANAGER of large Motor Car Factory, turning out well-known cars in quantities on the interchangeable system, DESIRES SIMILAR APPOINTMENT with established firm, syndicate, or capitalist. Very hard-working and energetic, and expert in cheap production and factory management, and on the design of motor cars, buses, engines, &c., and all the tools and jigs to produce same; has wide commercial knowledge and connection. Excellent opportunity for firm wishing to take up this branch. —Address, P345, Engineer Office, 33, Norfolk-street, Strand, W.C. P345

Marine Engineer, 1st B.O.T.'s Certificate, good testimonials for all service, 10 years sea experience, with some experience of electric light, WANTS EMPLOYMENT in Charge of Engines, Boilers, &c.—Address, P370, Engineer Office, 33, Norfolk-street, Strand, W.C. P370

Marine Engineer (25), 2nd B.T. certificate, 3 sea, 4 years' shop experience, SEEKS SIT., charge engines and boilers or drawing-office; excellent testimonials.—W. BONE, 95, Addison-gardens, London, W. P365

Marine Engineer (28), 7 Years' sea experience, 2½ drawing-office, thorough workshop and technical training, with large London firm, first-class B.O.T. certificate, and excellent testimonials, SEEKS POSITION ASHORE; charge of machinery or otherwise. Moderate salary.—Address, P366, Engineer Office, 33, Norfolk-street, Strand, W.C. P366

Marine Engineer (34), 1st B.O.T.'s Certificate, 12 years' sea experience, used to electric light, forced and natural draught boilers, SEEKS EMPLOYMENT in Charge of Engines and Boilers; highest references.—Address, P340, Engineer Office, 33, Norfolk-street, Strand, W.C. P340

Mechanical Engineer, Good theoretical and practical training, shop, and D.O., DESIRES POST. Excellent experience in producer gas plants, suction and pressure.—Address, P360, Engineer Office, 33, Norfolk-street, Strand, W.C. P360

Mechanical Engineer (28) Seeks APPOINTMENT; thorough general knowledge, sea and land experience, first-class certificates and testimonials.—Address, DUNNING, 128, Fenton-street, Leeds. P353

Position Wanted by Middle-aged PRACTICAL ENGINEER to look after and keep in repair Steam Motor Tractors, or Wagons, Traction Engines, Thrashing or Hauling Plant, &c.; also used to marketing and travelling.—Apply, THOMAS SCUTT, Blandford, Dorset. P347

Practical Engineer Seeks Posi- TION of TRUST, with prospects of advancement, hard-working, energetic and resourceful, accustomed to machine shop, also drawing-office work.—4, Anerley-road, Westcliff-on Sea. P334

Roads, Canals, Rivers, Improved RAILWAYS. — Experienced CIVIL ENGINEER, inventor of Utility of Canals and Rivers for Traffic.—Cure of Capt. COOK, Chester-road, near Birmingham. P351

Works Management. — Well- EDUCATED ENGINEER (32), excellent experience in management of engineering offices and works, DESIRES APPOINTMENT.—Address, P216, Engineer Office, 33, Norfolk-street, Strand, W.C. P216

Works Management.—Well- EDUCATED ENGINEER, M.I. Mech. E., of large experience in electrical and general engineering, energetic and up to date in high speed repetition work, and economical producer, is OPEN for RE-ENGAGEMENT. Experienced in commercial side also.—Address, 2177, Engineer Office, 33, Norfolk-street, Strand, W.C. 2177

Young Engineer (24), Shop, D.O. experience, two years at sea, fair electrical knowledge, DESIRES suitable SITUATION; highest references.—Address, P369, Engineer Office, 33, Norfolk-street, Strand, W.C. P369

Young English Automobile En- GINEER, having spent nearly 3 years in the States for experience, DESIRES POSITION in England; has made a special study of factory system, &c.—Address, P328, Engineer Office, 33, Norfolk-street, Strand, W.C. P328

Disengaged, Experienced Fore- MAN (33), accustomed to profitable manufacture, best work, small machinery, &c.—Address, P372, Engineer Office, 33, Norfolk-street, Strand, W.C. P372

Foreman Patternmaker Desires SIMILAR POSITION; good reference; nine years last situation.—JOHNSON, 182, Stafford-road, Southtown, Great Yarmouth. P362

As Foreign Correspondent or TRAVELLER (French, Spanish, Italian and German), REQUIRED by SMART EXPERIENCED MAN, with knowledge of machine tools, &c.—Address, P336, Engineer Office, 33, Norfolk-street, Strand, W.C. P336

Mr. Algernon Lewin Curtis, Mining and Mechanical Engineer, Chatteris, Cambs., has much pleasure in informing his clients that he is shortly going to America on a third commercial mission of inquiry this year, and is OPEN to TRANSACT BUSINESS (either buying or selling) for reputable firms. Special attention paid to machinery for reducing working costs. Terms by arrangement payable on completion of contract. P339

Representative.—Mech. Engineer, with commercial experience and best connections among industrial and Government administrations in France, Germany, Austria, Belgium, Holland, organiser and salesman, speaking English, French, and German, WANTS EMPLOYMENT as REPRESENTATIVE; best references.—Address, P350, Engineer Office, 33, Norfolk-street, Strand, W.C. P350

Traveller, Experienced, with good connection among exporters, engineers, contractors also knowledge of iron trade, DESIRES to REPRESENT good FIRM.—Address, P367, Engineer Office, 33, Norfolk-street, Strand, W.C. P367

Young Man Wishes Employment in Engineering Shop or Export Metal Merchants' as CORRESPONDENCE CLERK; Spanish, French, Italian; previous business experience.—Address, P346, Engineer Office, 33, Norfolk-street, Strand, W.C. P346

TO CLERKS OF WORKS, FOREMEN, &c.

The National Association for EX-SOLDIERS, 119, Victoria-street, S.W. (Telephone, 30 Westminster), SUPPLIES MEN of good character only as navvies, masons, bricklayers, porters, labourers, caretakers, carmen, horsekeepers, night watchmen, timekeepers, &c. Characters up to date. No fees.—Apply, SECRETARY, as above. 1178

Motor and General Engineering. —WANTED to PLACE SMART YOUTH, just completing technical college course, as IMPROVER or APPRENTICE.—Address, P342, Engineer Office, 33, Norfolk-street, Strand, W.C. P342

A Firm of Engineers in the East End have VACANCY in their Drawing-office for PUPILS; must be intelligent and sufficiently educated. No premium required. Good opportunity for willing and industrious youths.—Write, A. F. O., care of Willing's Advertisement Offices, 73, Knightsbridge, London. 2252

Articled Pupil.—A Large Firm of Engineers in the Midlands, employing upwards of one thousand hands, have a VACANCY for a PREMIUM APPRENTICE.—Address, 34, Engineer Office, 33, Norfolk-street, Strand, W.C. 34

Engineering Pupil.—A Firm of Engineers in the West of England have a VACANCY for a premium PUPIL.—Address, 7, Engineer Office, 33, Norfolk-street, Strand, W.C. 7

Engineering Pupil. — Firm (Government Contractors), employing 500 hands, have VACANCY; varied classes of work done, affording excellent opportunities; premium moderate.—Address, 2, Engineer Office, 33, Norfolk-street, Strand, W.C. 2

Premium Pupil. — Consulting Mechanical Engineer, London, WILL GIVE his PERSONAL ATTENTION to ONE PUPIL. Can introduce to workshops.—Address, P279, Engineer Office, 33, Norfolk-street, Strand, W.C. P279

Pupil. — All-round Insight and thorough practical training in shops and office. Country town. Premium £60, returnable as salary.—Address, 2103, Engineer Office, 33, Norfolk-street, Strand, W.C. 2103

Surveying, Levelling, &c.— Excellent opportunity for ACQUIRING thorough practical INSTRUCTION on Extensive and Varied Surveys.—Address, P305, Engineer Office, 33, Norfolk-street, Strand, W.C. P305

Wanted, Active Partnership; could invest £1000 with services.—Address, P327, Engineer Office, 33, Norfolk-street, Strand, W.C. P327

A Young English Mechanical Engineer (26), with foreign experience, speaking French and German, SEEKS EMPLOYMENT, London preferred; could introduce capital later. — Address, ENGINEER, 8, Birchin-lane, London, E.C. 2268

All Inventors Requiring Capital should WRITE or CALL CROZIER and CO., Patent Experts, 110 and 111, Strand, London, who have many capitalists on their books who will buy good, simple inventions. No result, no charge. Advice free. P376

Engineering Concern (Limited Co.), having proved patented special machine and orders in hand more than they can produce in 10 months, have OPENING for a YOUNG ENGINEER to take active part in Management and join the Board. Required to take up £10,000 debenture—£9500 will be retired—and £10,000 ordinary shares. Capital now employed £50,000. The increase will double output, for which the sale is assured, and the business is a monopoly and remunerative.—Principals only reply to P.210, W. H. Smith and Son, Advertising Agents, Blackfriars, Manchester. 2180

Engineer, with £5000, Wanted in large up-to-date London Engineering Works; good dividends and adequate salary; old-established genuine concern. — Address, 2226, Engineer Office, 33, Norfolk-street, Strand, W.C. 2226

Motor Launch Works.—Young ENGINEER, with £500 to £1000, WANTS to JOIN established FIRM; has much experience in Marine Work.—Address particulars to 2227, Engineer Office, 33, Norfolk-street, Strand, W.C. 2227

Partner or Investor with Ap- POINTMENT WANTED, Engineering Merchants, Motor Agency, and Repair Works; good prospects; state age, experience, and capital.—Address, P354, Engineer Office, 33, Norfolk-street, Strand, W.C. P354

Partner Wanted, Engineer. Opening of great promise in Specialities for pushing man. — Address, P299, Engineer Office, 33, Norfolk-street, Strand, W.C. P299

Partner, with about £2000, WANTED, to join advertiser (who will invest a similar amount), to take over paying section of an old-established copper and engineering business in the Midlands. Principals only.—Address, P329, Engineer Office, 33, Norfolk-street, Strand, W.C. P329

Partner, with £500 to £1000, WANTED in an Electrical Instrument Manufactory, London; good opening for anyone capable of managing and well up in electricity.—Address, 2228, Engineer Office, 33, Norfolk-street, Strand, W.C. 2228

Partnership.—A Highly Qualified CIVIL ENGINEER (33), with sound knowledge of railway work and capital of £7000, REQUIRES PARTNERSHIP in established firm of Civil Engineers in London. — Apply, Messrs. ARNOLD and CO., 60, Queen Victoria-street, E.C. 2205

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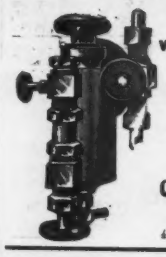

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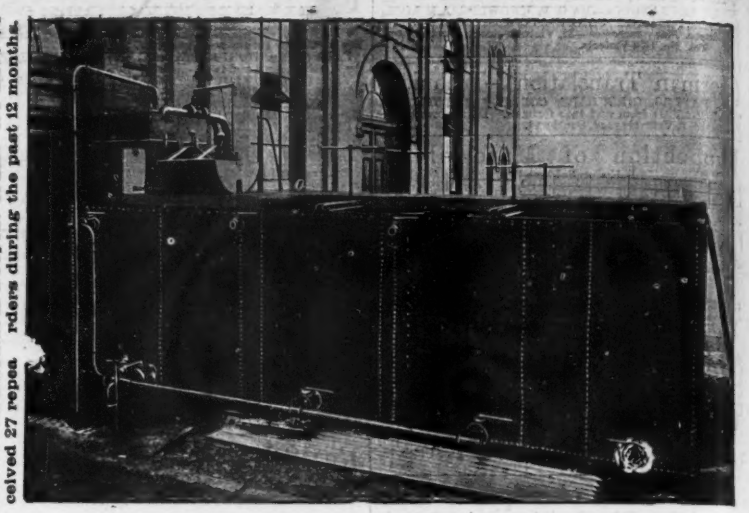

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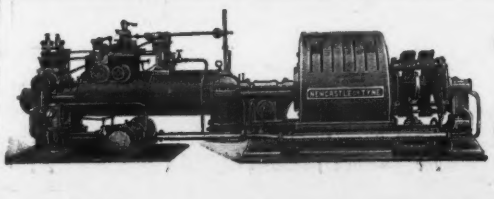

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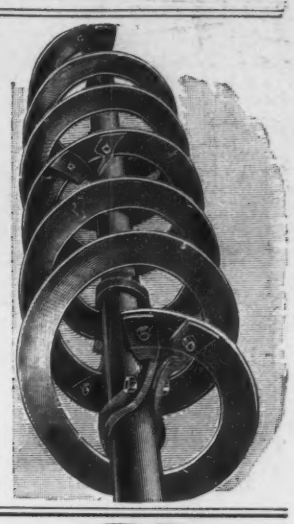

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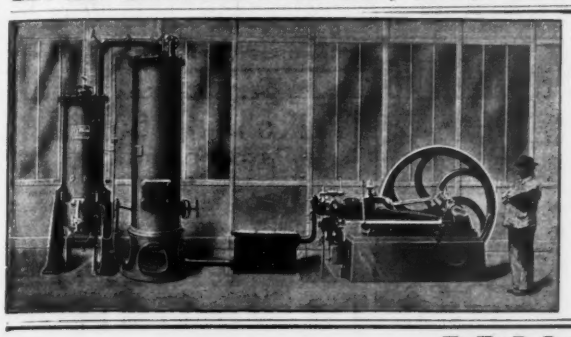

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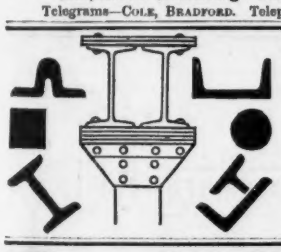

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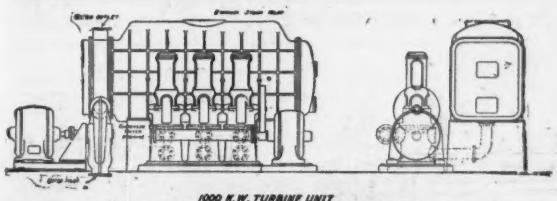

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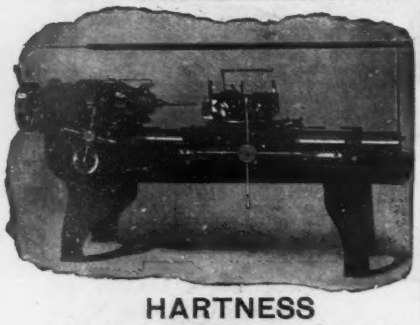

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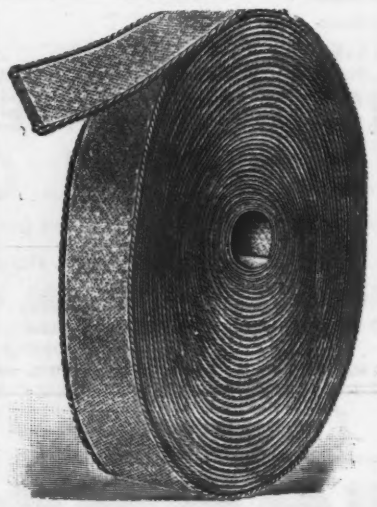

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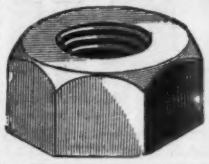

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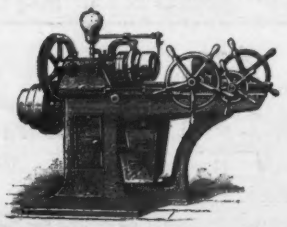

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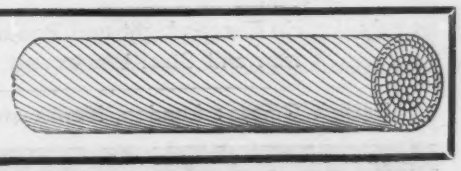

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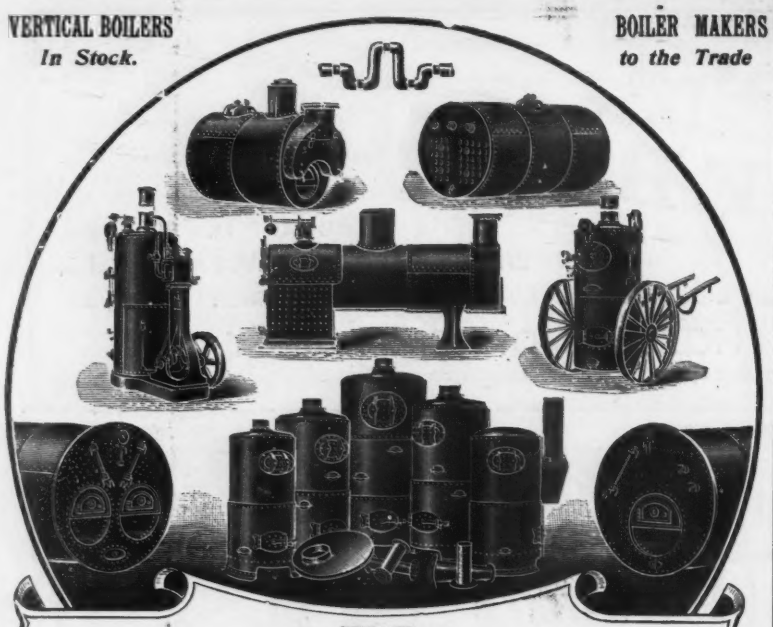

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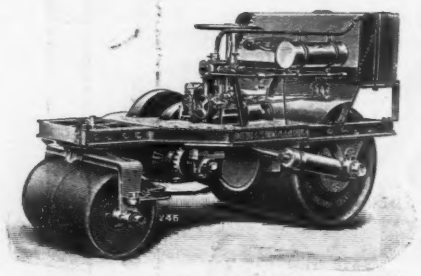

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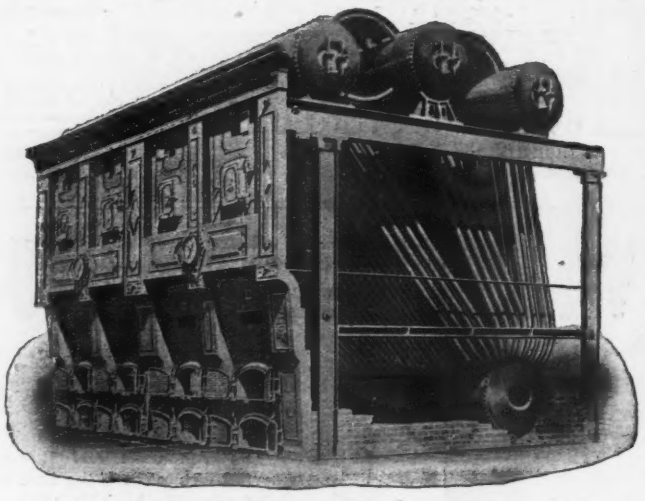

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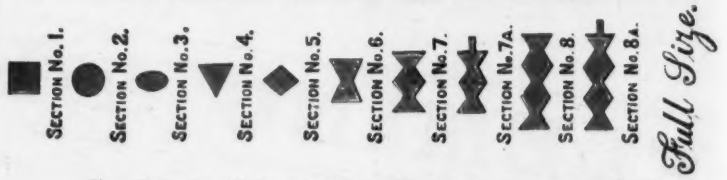

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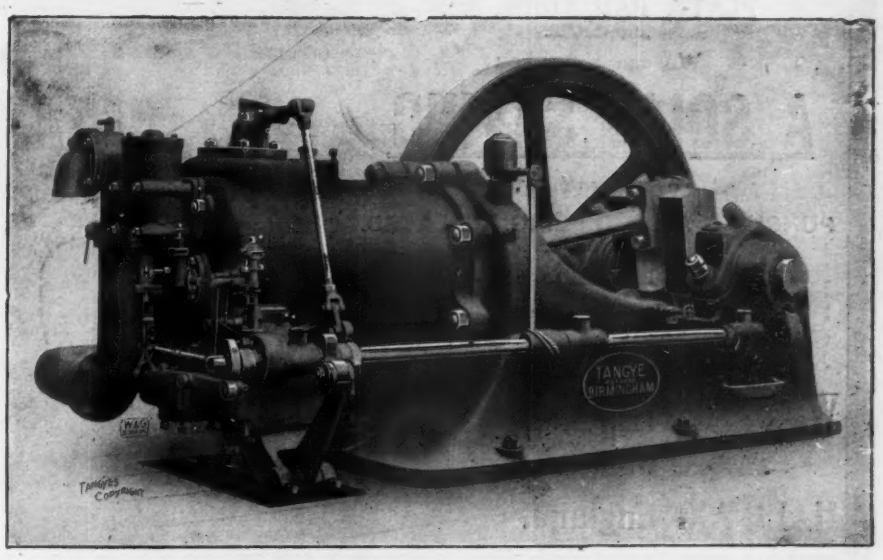

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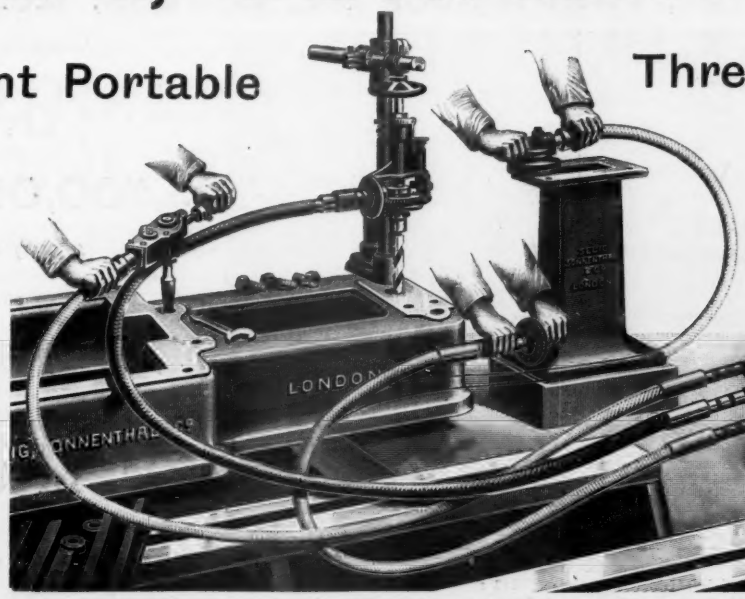

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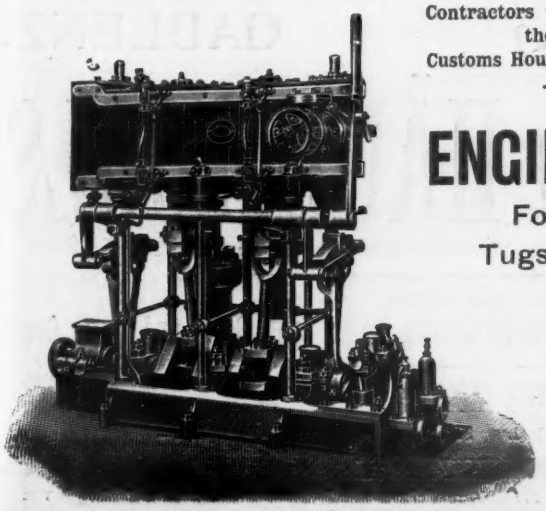

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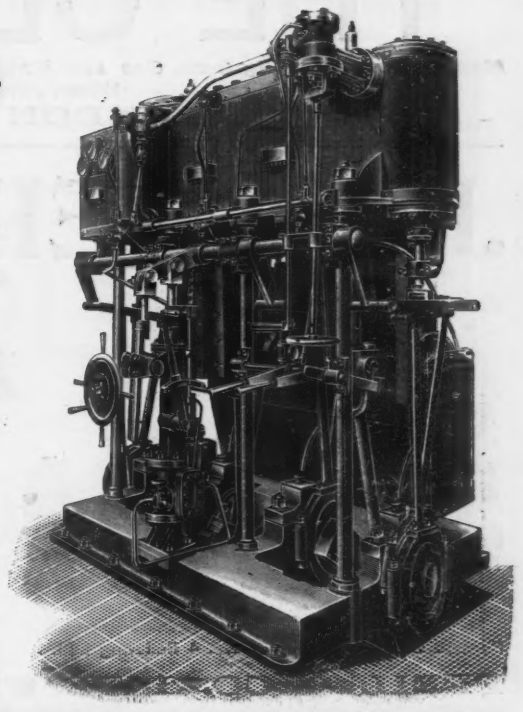

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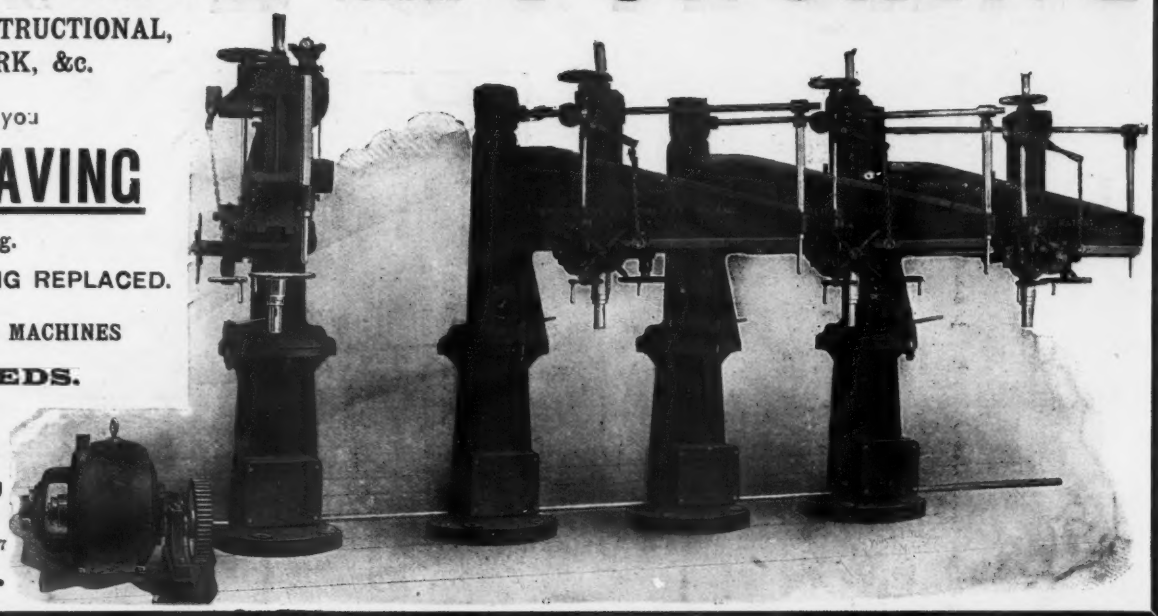

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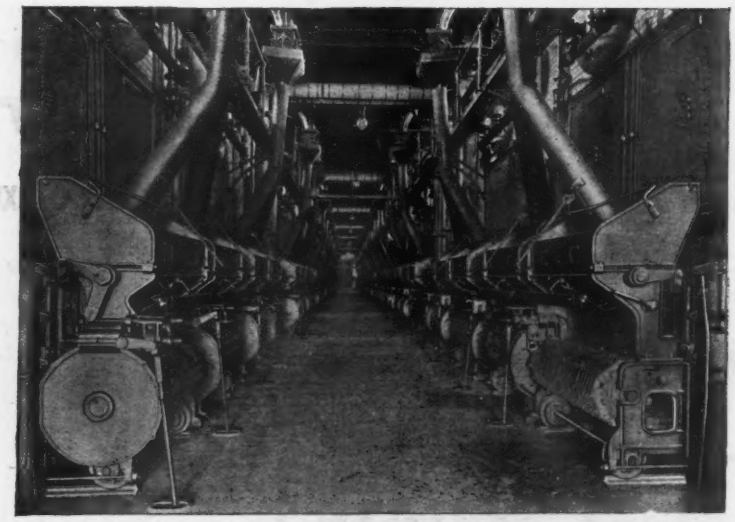

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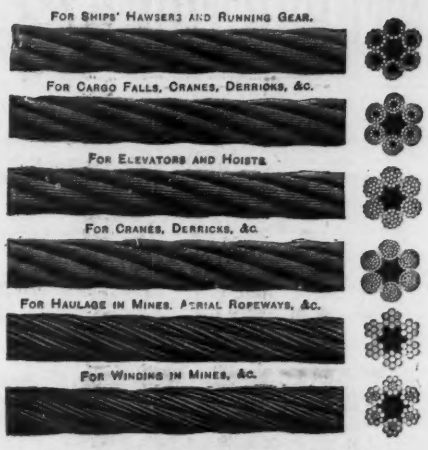
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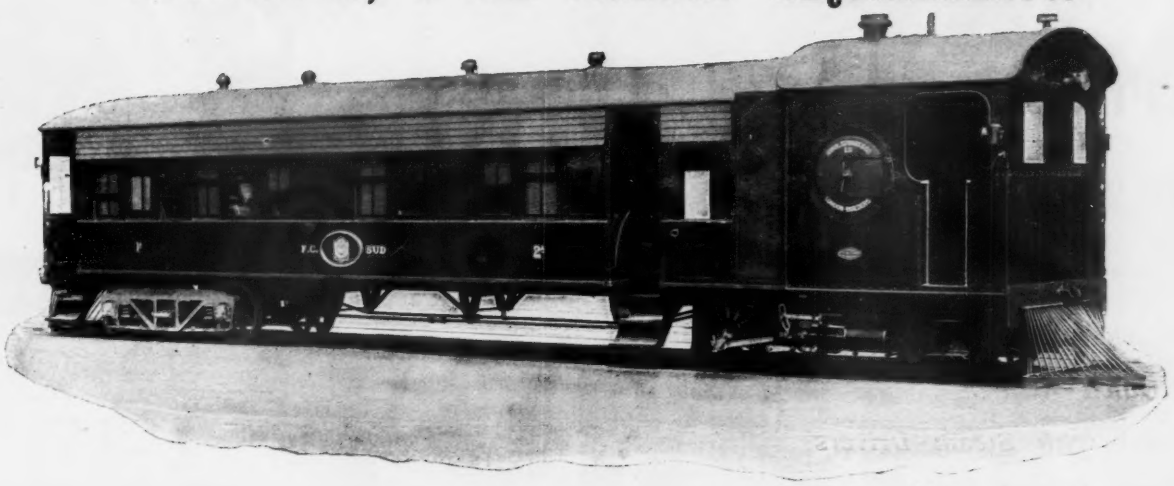

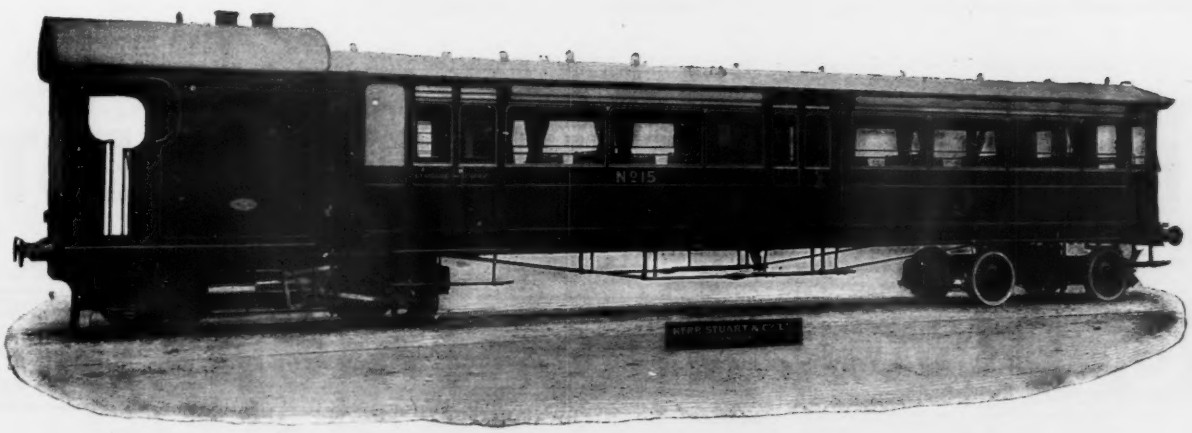

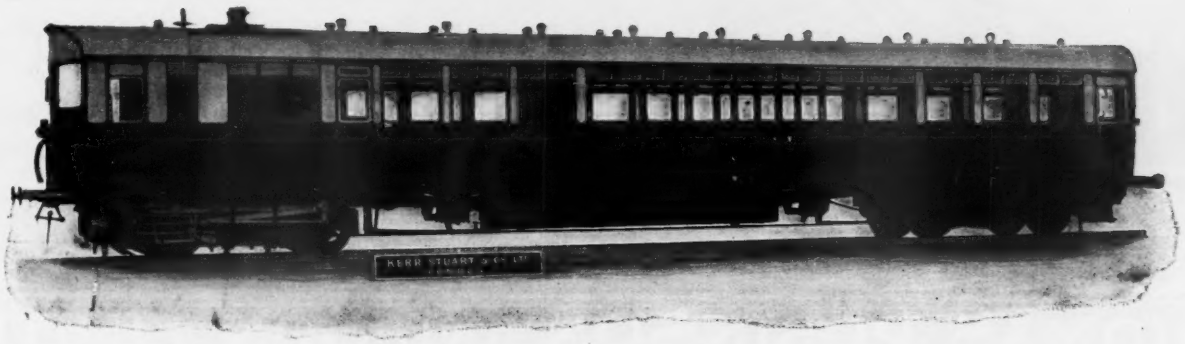

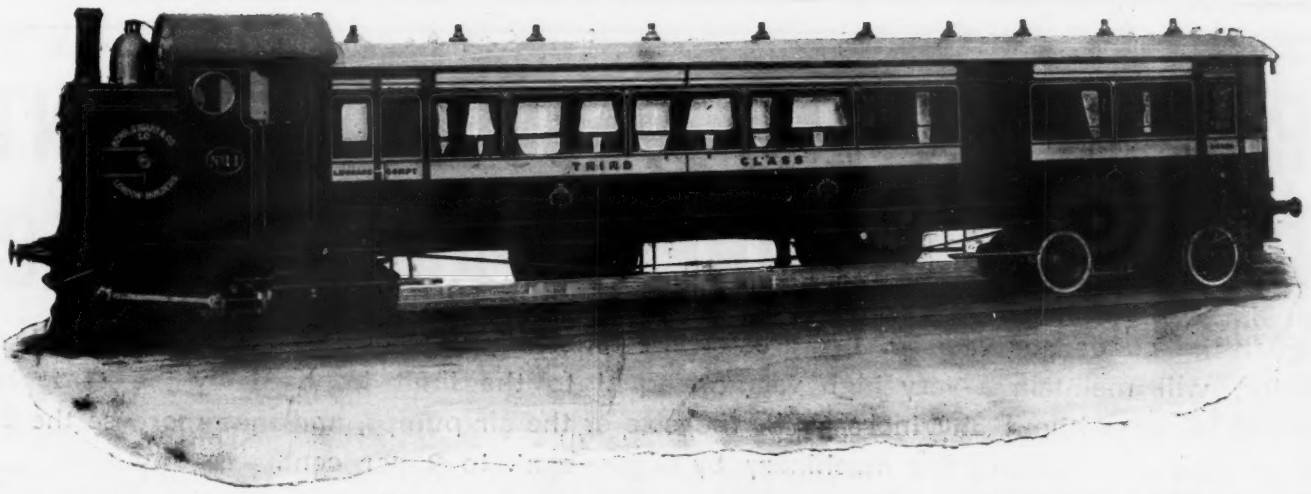

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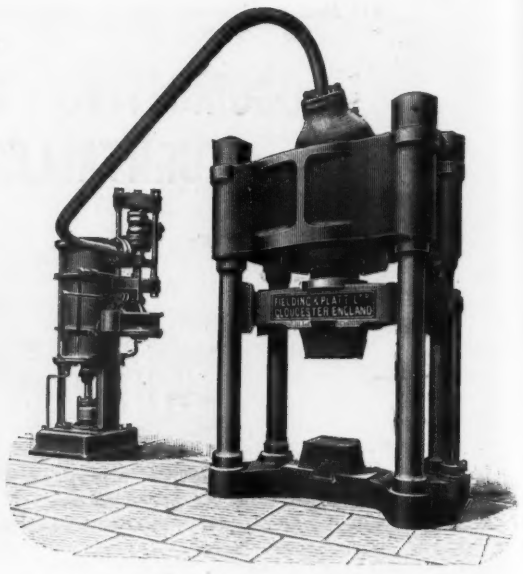

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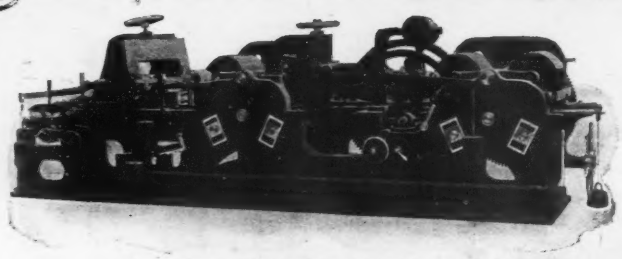

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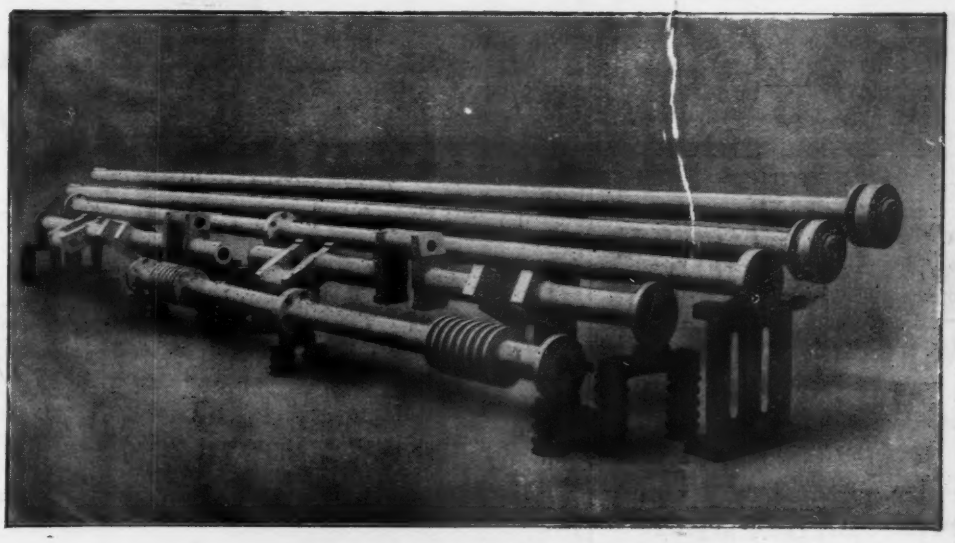

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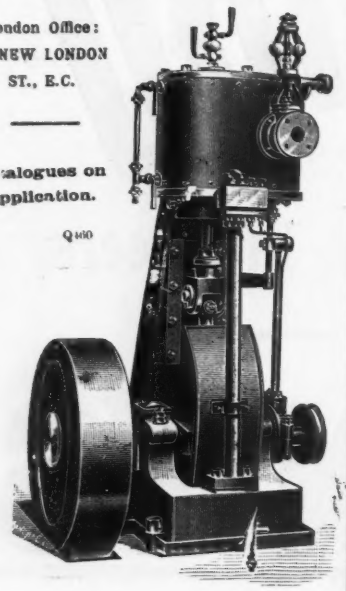

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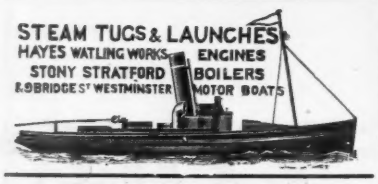

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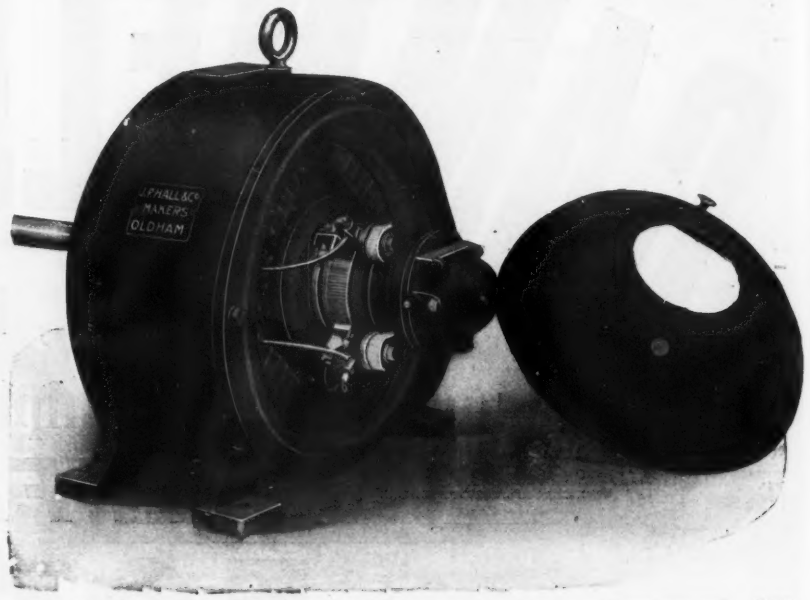

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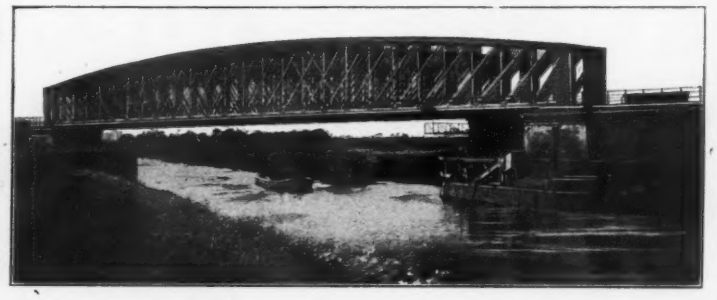

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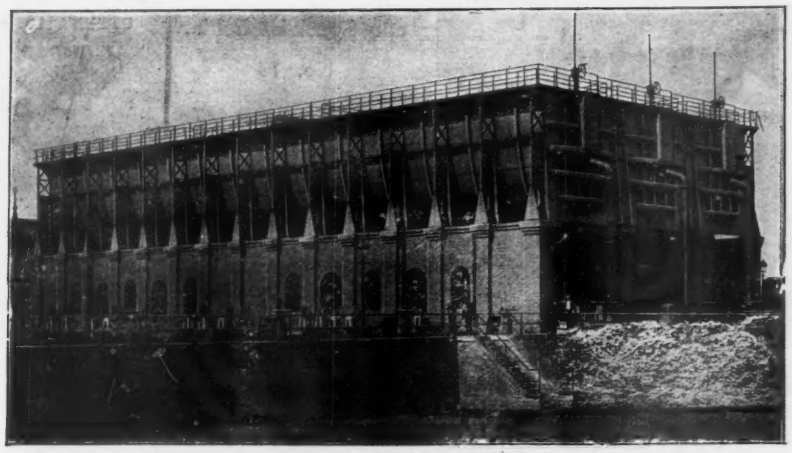

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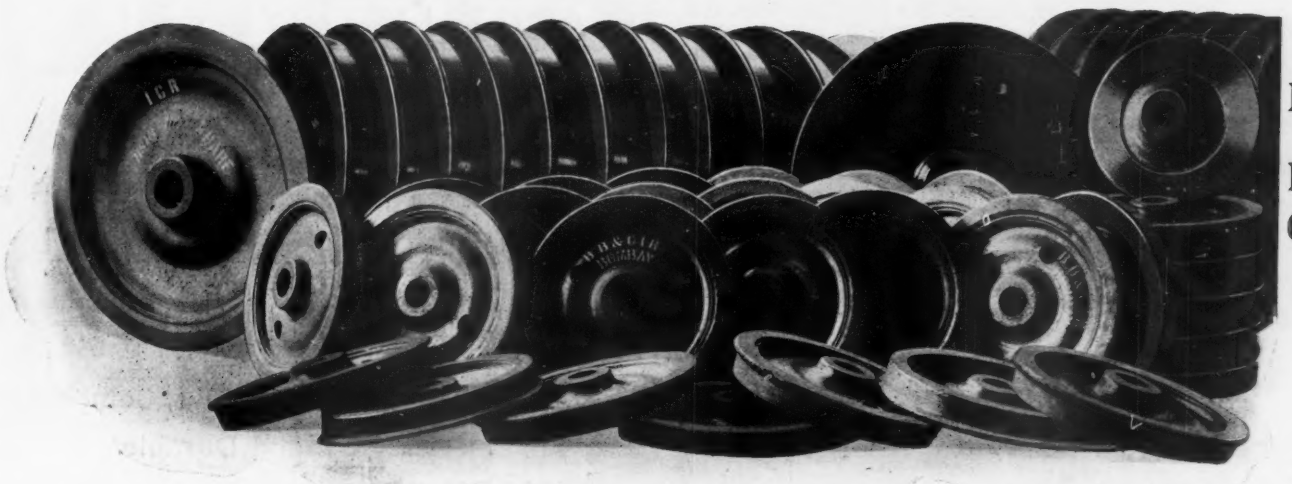

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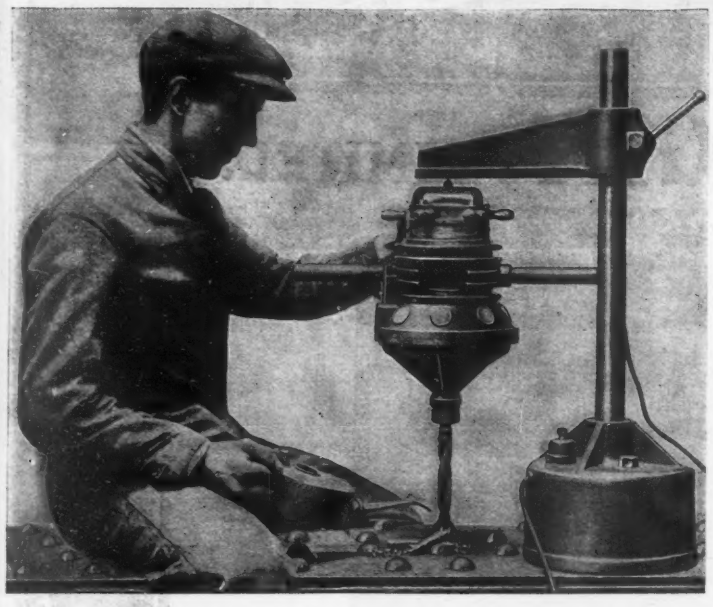

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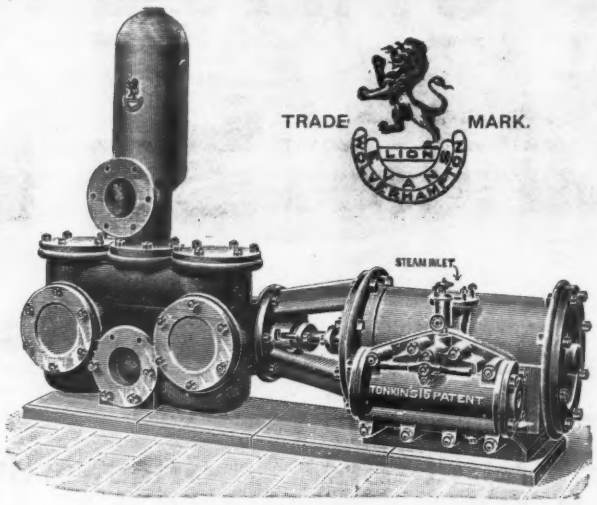

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in. in. ft.	ft. in.	m. sec.			cut. retn.	cut. retn.
24 × 24 × 6	6 3½	1 8	126	111	90 225	78 210
36 × 36 × 20	20 3	10 12	405	40	24 163	23 150
(With 9-speed	20 3	6 14	405	65	42 163	41½ 150
gear box for cut)	20 3	4 46	405	85	61 163	60½ 150
42 × 42 × 20	22 6	6 39	450	68	45 145	44½ 141
*42 × 42 × 12	11 0	2 36	220	84	—	57½ 165
60 × 60 × 12	13 0	4 8	260	63	42½ 140	42 127

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* With variable speed motor for the cut and constant speed motor for the return. This Machine is doing 100 per cent. more work than its predecessors.

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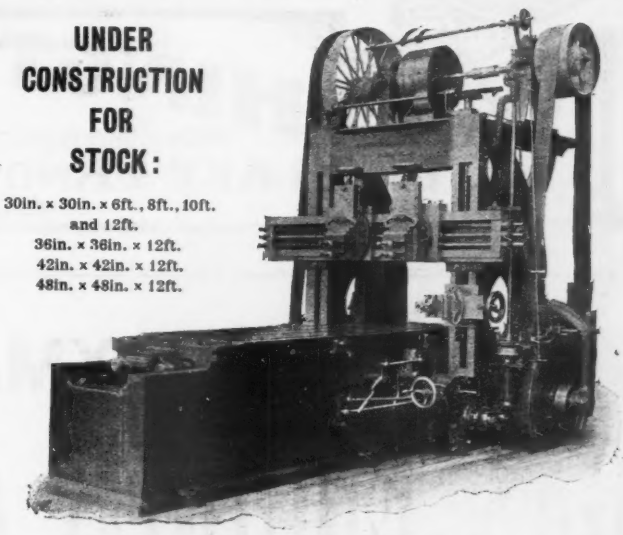

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Cutting Speed 20 to 60ft. per min.; Return Speed 140 to 170ft. per min.

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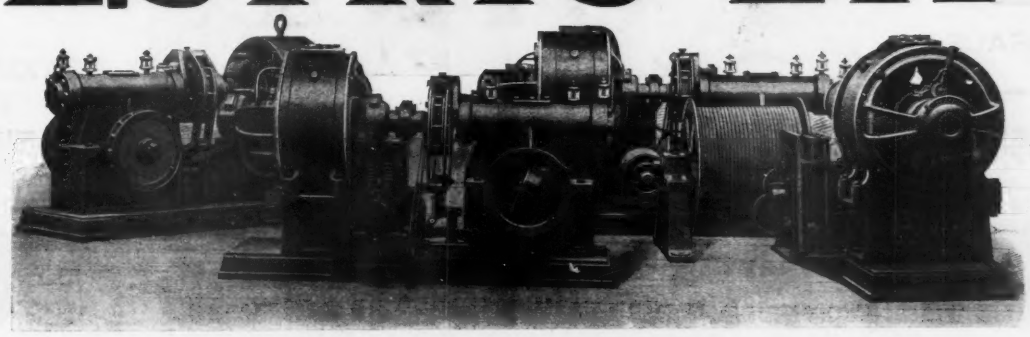

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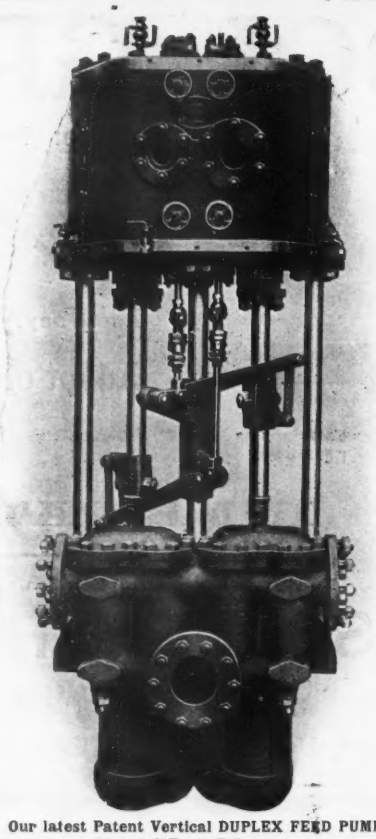

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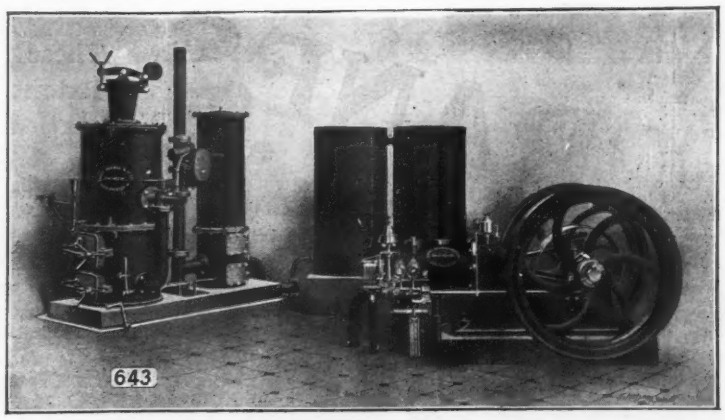

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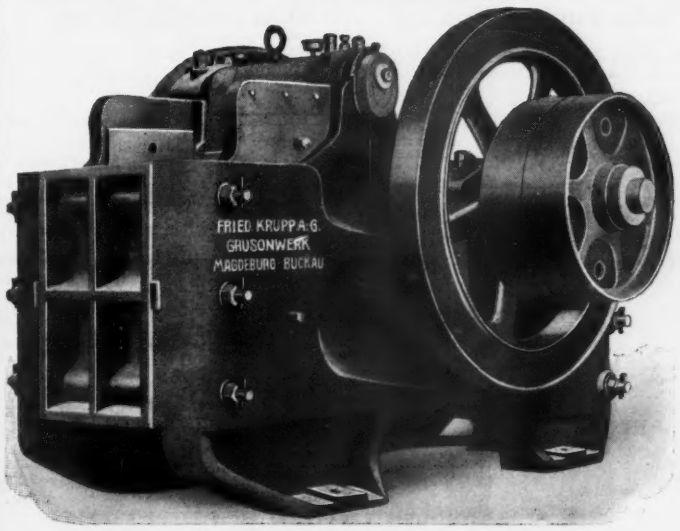

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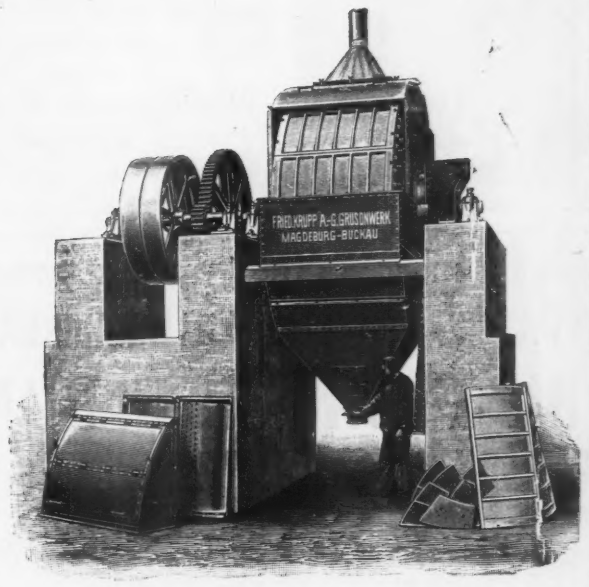

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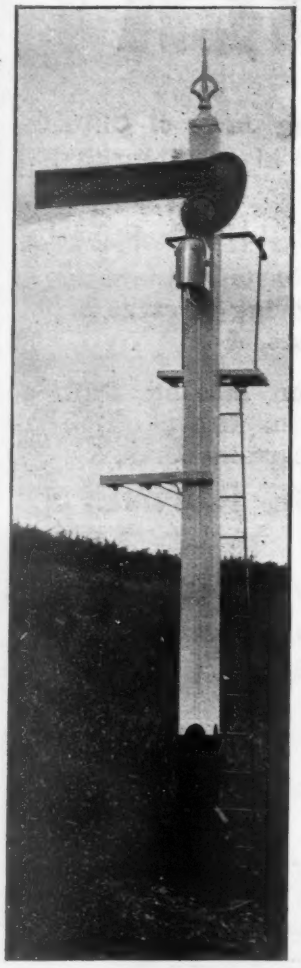

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860

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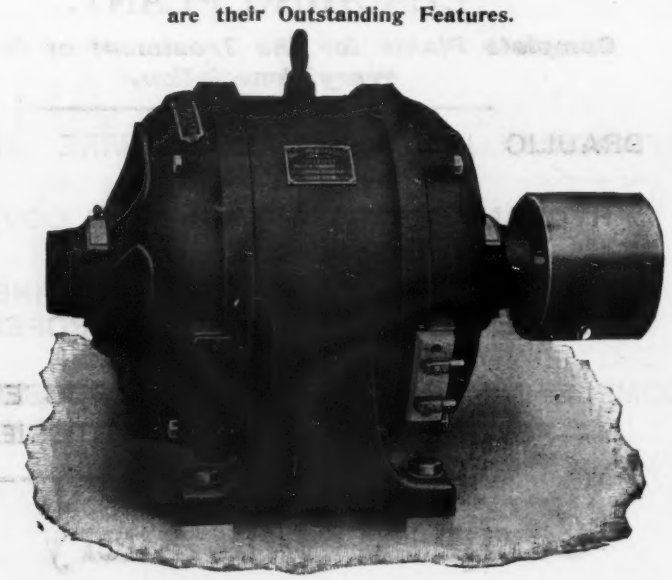
INDUCTION MOTORS

These Motors represent Modern Electric Practice at its best. High Efficiency & Power Factor, Good Overload Capacity and Sound Mechanical Construction are their Outstanding Features.



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Bruce Peebles
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Branches—Manchester, Newcastle, Cardiff, Shanghai, Johannesburg, Pernambuco, and London (Ontario).
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PATENT SLIDE VALVE UNCHOKEABLE
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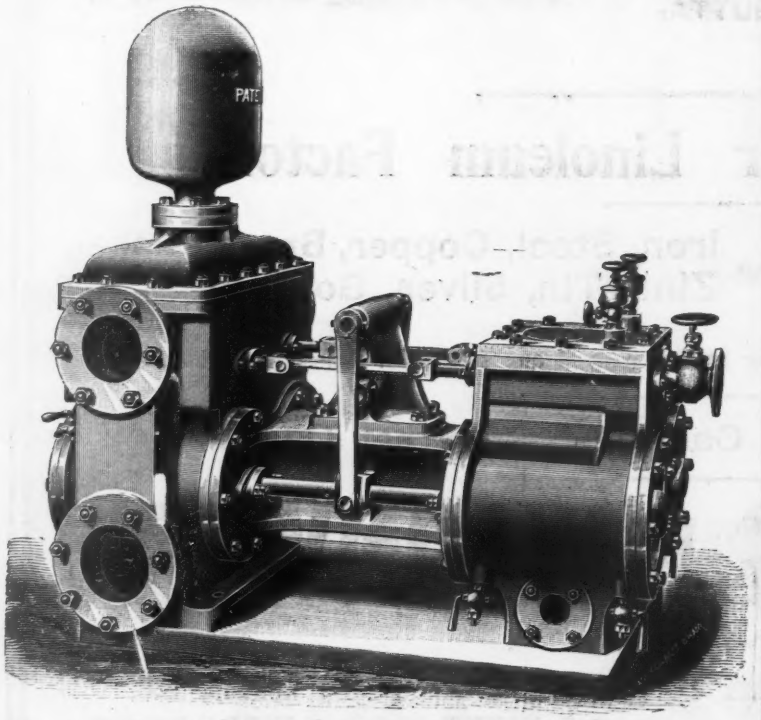
2000 IN USE.
CAPACITIES, 35—300 TONS PER HOUR.



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GATESHEAD.
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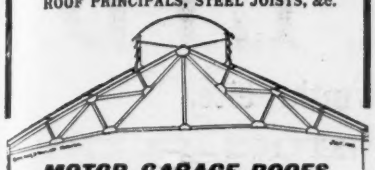

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OUR SPECIALITY.
Special Estimates on receipt of particulars of requirements. Z133
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FOR ALL PURPOSES, AND
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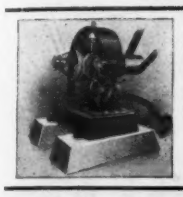

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Supplied to work off Hydraulic Power Mains, 700 lbs. pressure.
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PORTABLE OR STATIONARY.
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Sole Makers—GOODWIN, BARSBY & CO., Engineers & Ironfounders, LEICESTER. Z167

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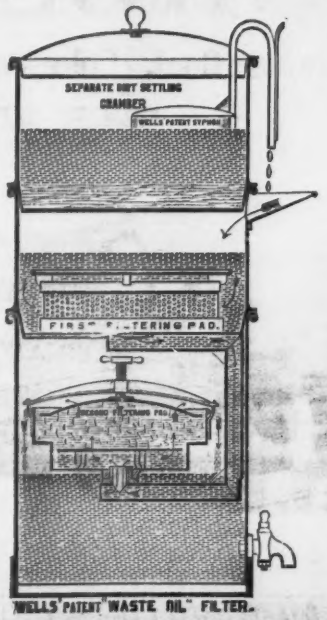

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THE "White" Compressor
in all Styles, all Sizes, for all Powers, and all Purposes.
Tandem Type for Pneumatic Tools, fitted with Automatic Air Release and Slowing Mechanism. 8M22

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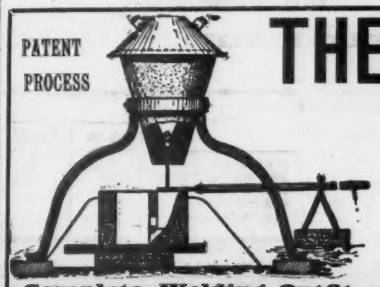

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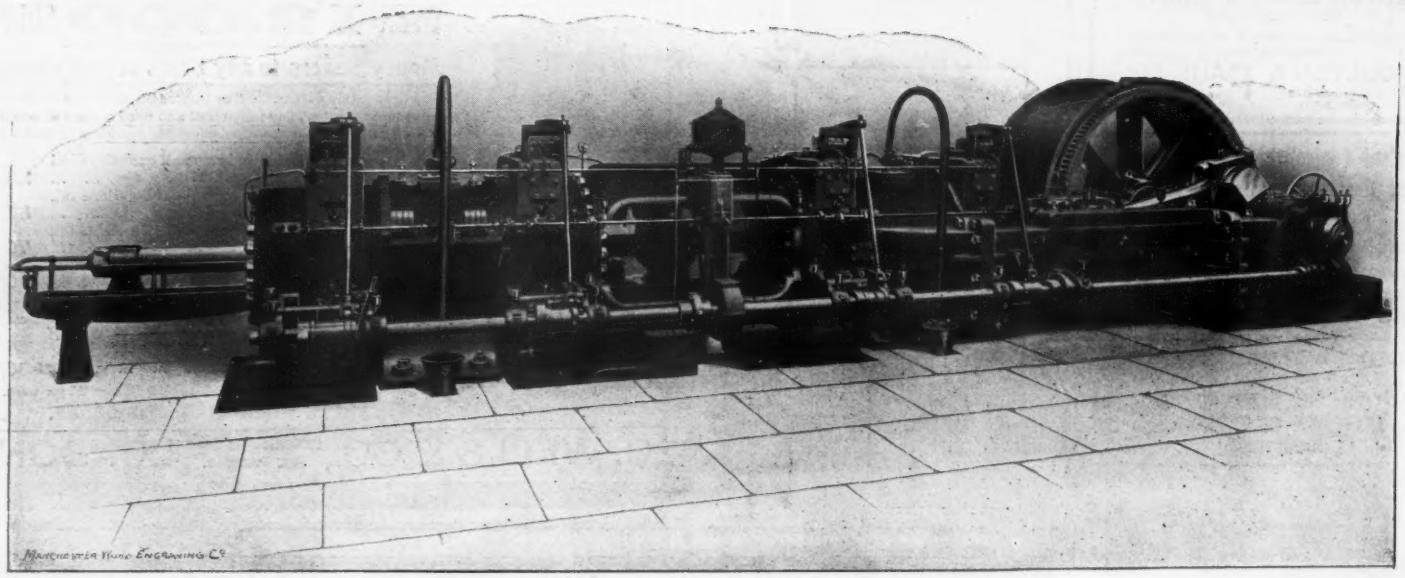

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Full Particulars and Lists application.

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	No. 0.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
Diameter of Ram ..	1	1⅞	1⅞	2½	2⅝	3½	3½	4
Diameter of Cylinder	2	2½	3	3½	4½	5½	5½	7
Length of Stroke ..	2	2½	3	4	5	6	6	6
Gallons per hour ..	90	130	210	440	600	1000	1080	1280
N.H.P. of Boiler ..	4	8	16	30	45	70	72	80

Sizes.	DOUBLE ACTION.					
	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Diameter of Ram ..	1½	2	2½	3	2½	5
Diameter of Cylinder	3	3½	4½	5½	6	7
Length of Stroke ..	3	4	5	6	6	6
Gallons per hour ..	420	800	1250	1820	2160	4000
N.H.P. of Boiler ..	32	70	90	120	150	250

O23

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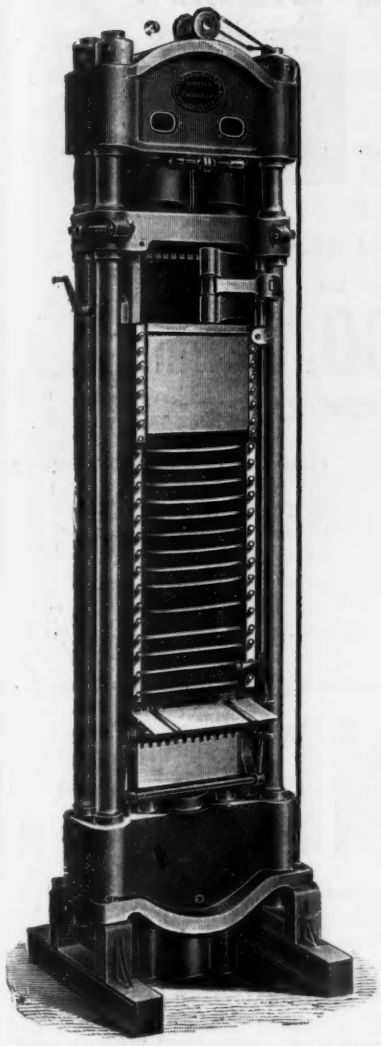

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For Baling and Finishing COTTON, JUTE and other FIBRE.
The patent "Octopus" press and Wilson's patent compound press for finishing the bale to the proper limits by two operations in the same press.

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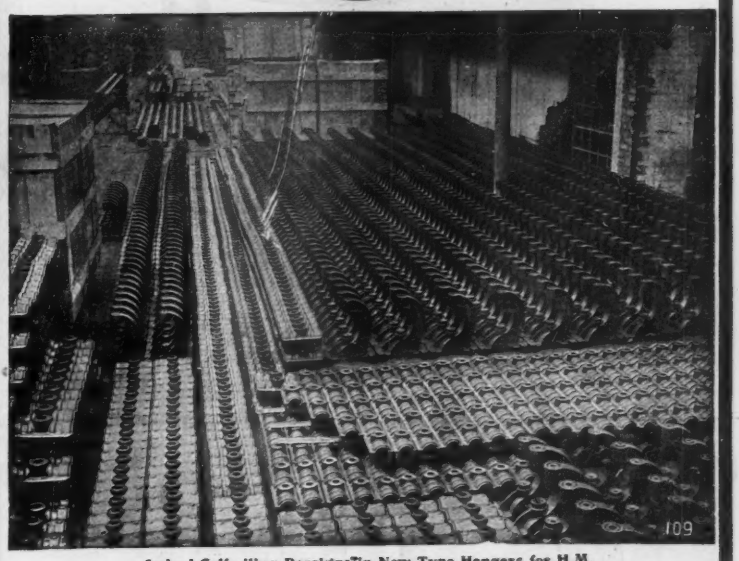

Swivel Self-oiling Bearings in New Type Hangers for H.M. Government Small Arms Factory, India.

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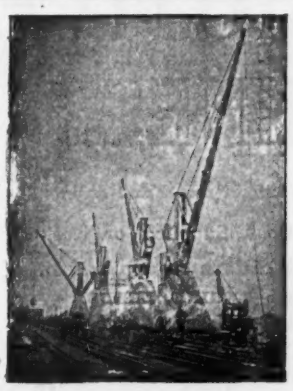

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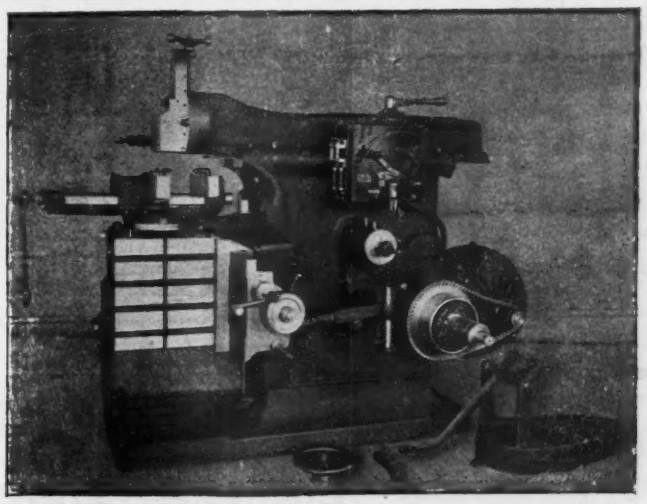

3 H.P. Morse Chain Drive, 1200 R.P.M. on 13½in. centres. Sprockets, 16 and 57 teeth; chain, ⅜in. pitch, 1¾in. wide; Speed, 1000ft. per minute.

Morse Chain

The most efficient power transmitter made. It is silent when running at high speed and can be used with sprockets as small as 13 and as large as 130 teeth. The transmission of power from electric motors to machine tools is accomplished with maximum efficiency and economy by the Morse Chain.

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Short Centre Drive.

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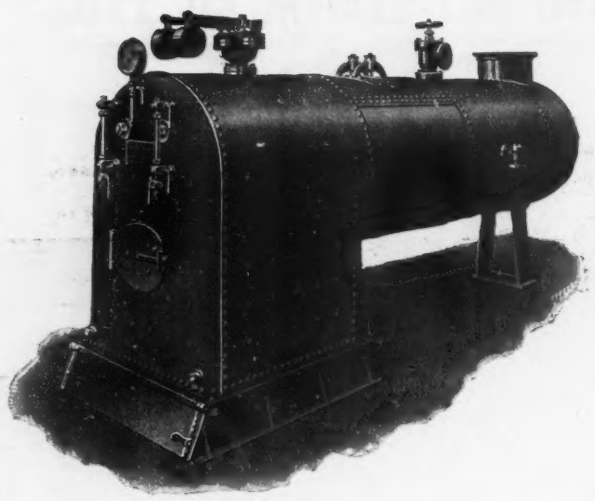

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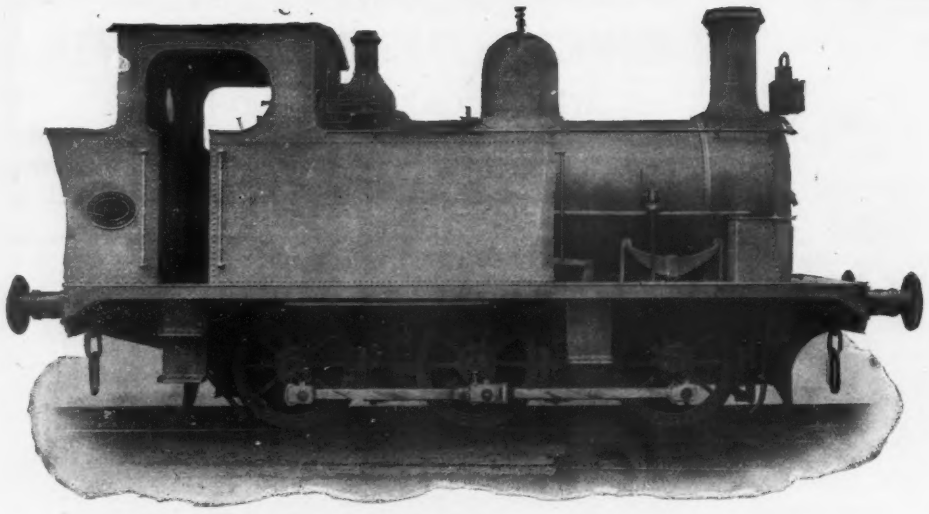

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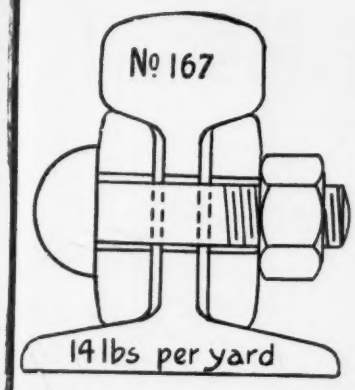
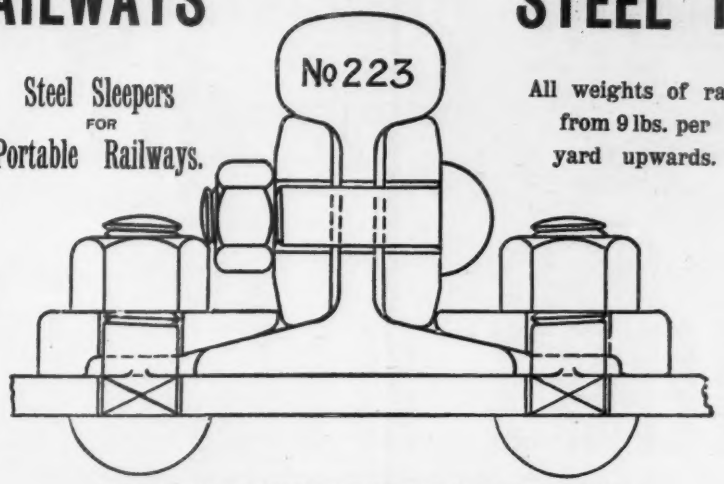


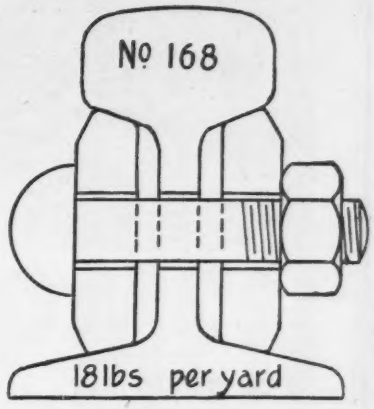
Steel Sleepers FOR Portable Railways.



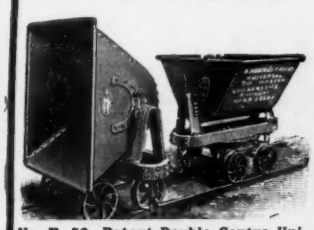
STEEL TROUGH OR CORRUGATED SLEEPER, WITH BOLTED CLIPS.

STEEL TIPPING WAGONS

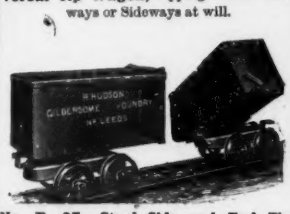
All weights of rail from 9 lbs. per yard upwards.



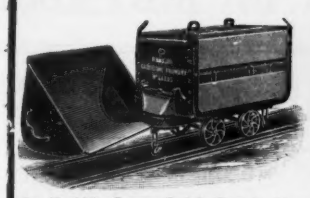
No. E. 96—Patent Double Centre Steel Side Tip Wagon (Diamond Fields Pattern), with jockey for wire rope haulage.



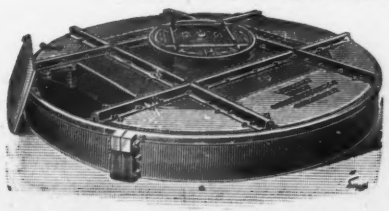
No. E. 50—Patent Double Centre Universal Tip Wagon, tipping either Endways or Sideways at will.



No. E. 97—Steel Side and End Tip Wagon, with Flapping Door (for hand use).



No. E. 193—Crane Brick Box to fit on standard side tip wagon underframe.

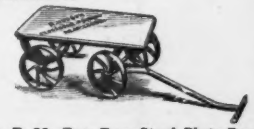


No. E. 115—Self-contained Turntable.

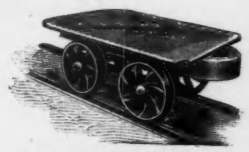
No. E. 1—Patent Steel End Tip Wagon.

No. E. 162—Patent Steel Double Side Tip Wagon, with screw brake and platform.

No. E. 171—Coke-charging Barrow, with end door.

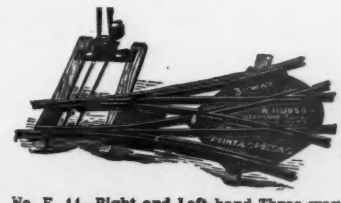


No. E. 22—Two Tons Steel Plate Bogie. "Practically Indestructible." Always in Stock. Platform about 56in. long by 30in. wide. Height 23in. Weight about 4 cwts. 18in. Steel Wheels.

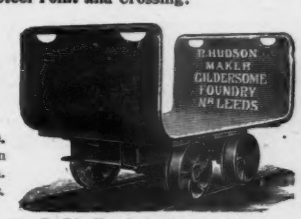


No. E. 58—Steel Plate Bogie.

No. E 15—Steel Cage. With Safety Grippers and Fallers complete.

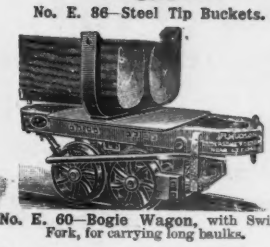


No. E. 11—Right and Left-hand Three-way Steel Point and Crossing.



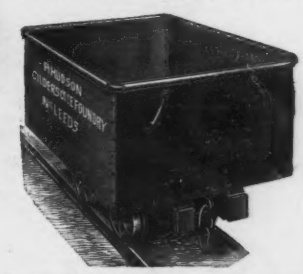
No. E. 76—Hand Trolley, made to carry any weight, or to suit any rail gauge.

No. E. 86—Steel Tip Buckets.

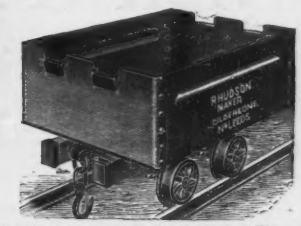


No. E. 60—Bogie Wagon, with Swivel Fork, for carrying long baulks.

No. E. 59.—Patent Double Side Tip Wagon. To work with ordinary Railway Wagons made to any size. Can be tipped by one man.



No. E. 101—Steel Plate Colliery Truck.



No. E. 104—Pressed Steel Mining Wagon.

No. E. 106—Steel Hopper Wagon, with sliding door worked by lever.

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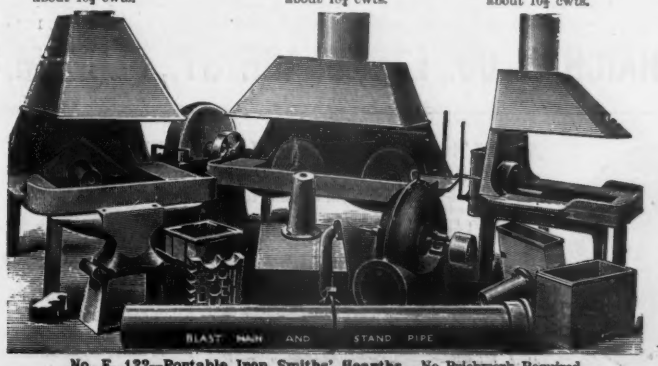
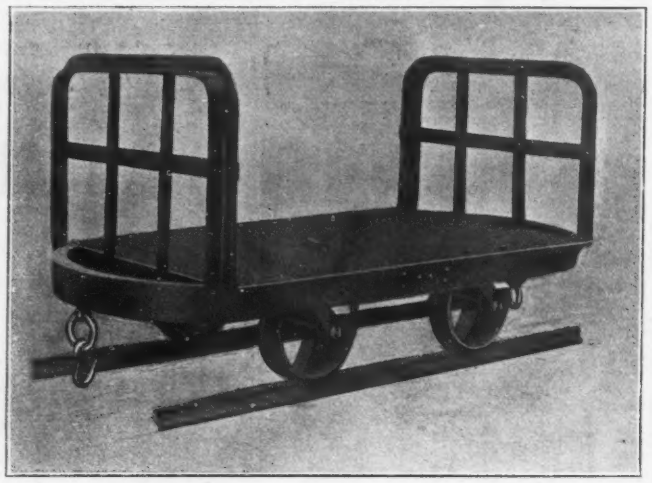
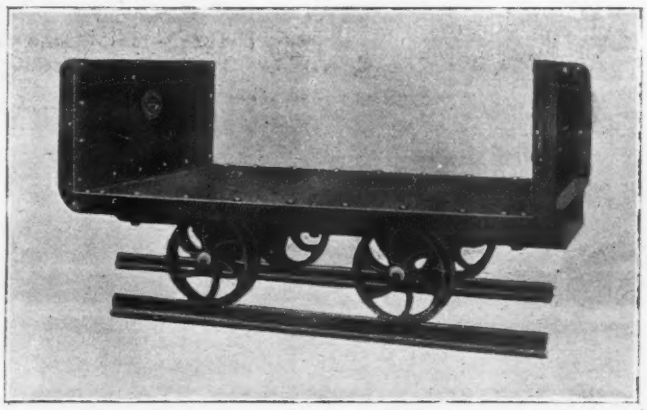


No. E. 122—Portable Iron Smiths' Hearths. No Brickwork Required.

Platform Waggons.



These Waggons are particularly suitable for **Quarries, Engineering Works, Foundries, Arsenals, Wharves,** or for any class of work where the carrying of heavy, rough goods is necessary. The underframe is of channel steel, securely stayed and riveted, and the floor can be either steel or timber. Write for Catalogue No. 107.



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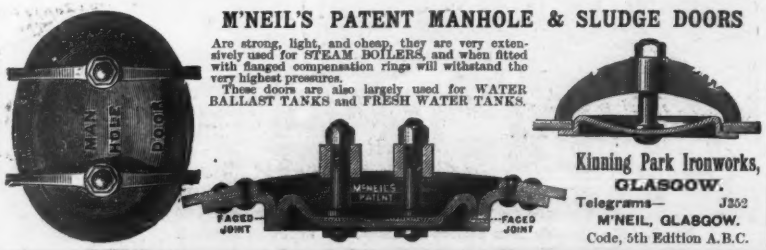

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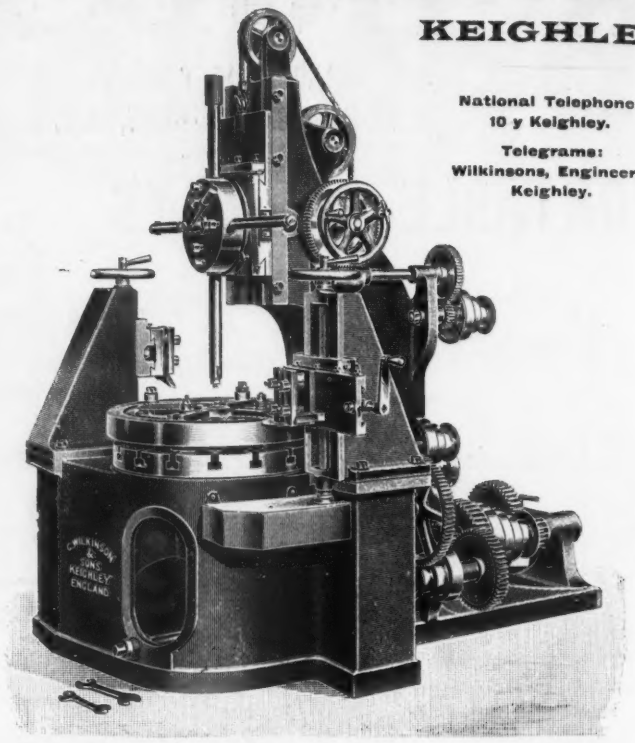

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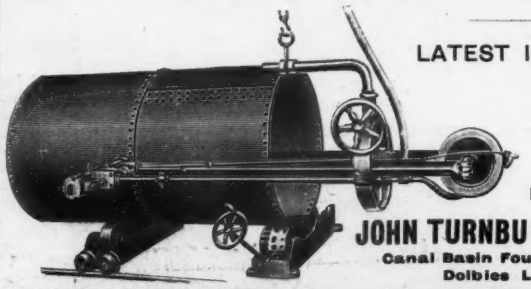

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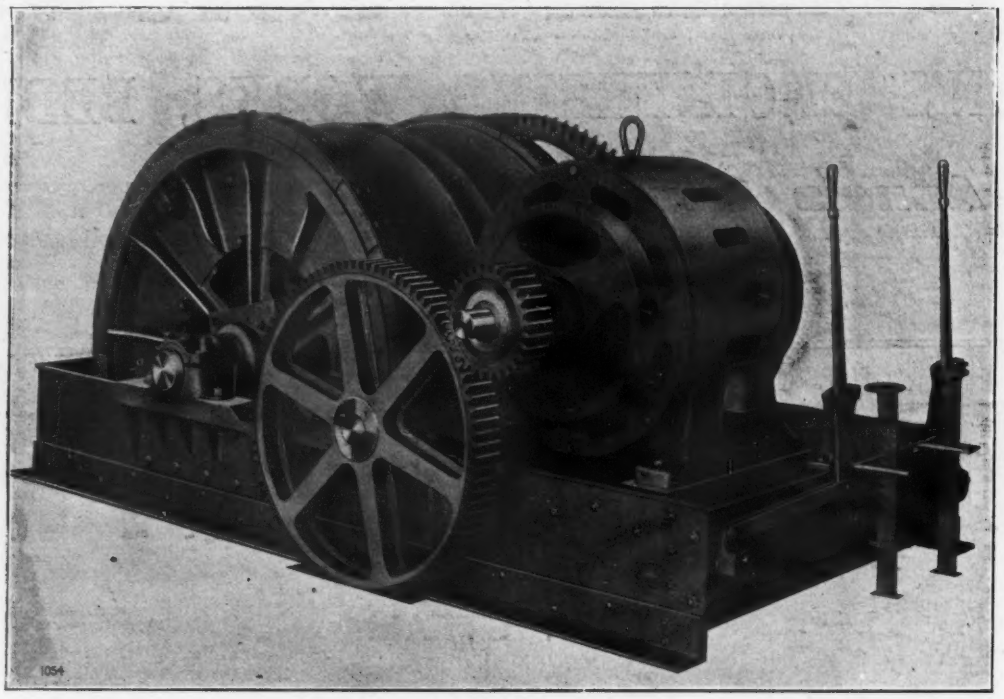

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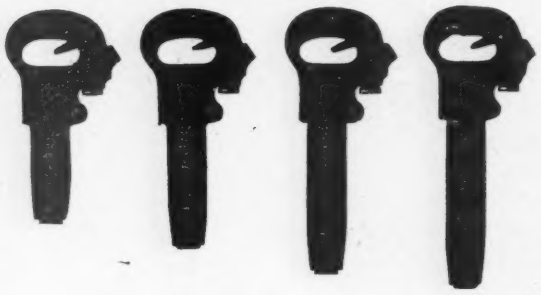

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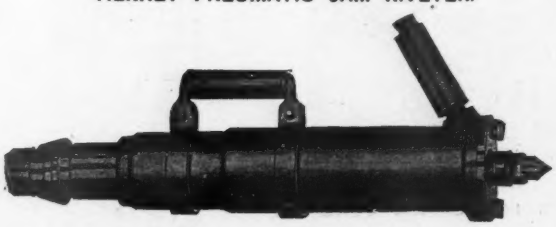

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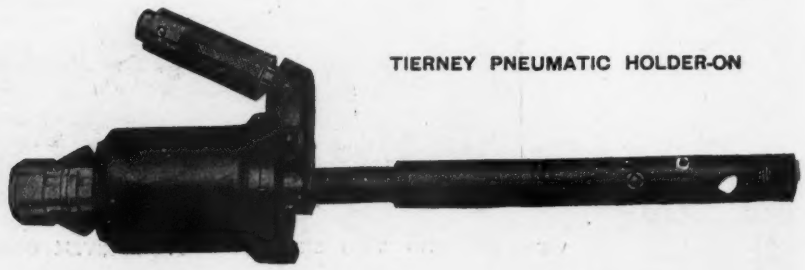

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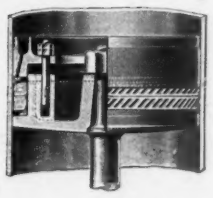

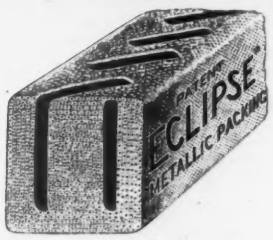

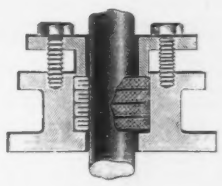

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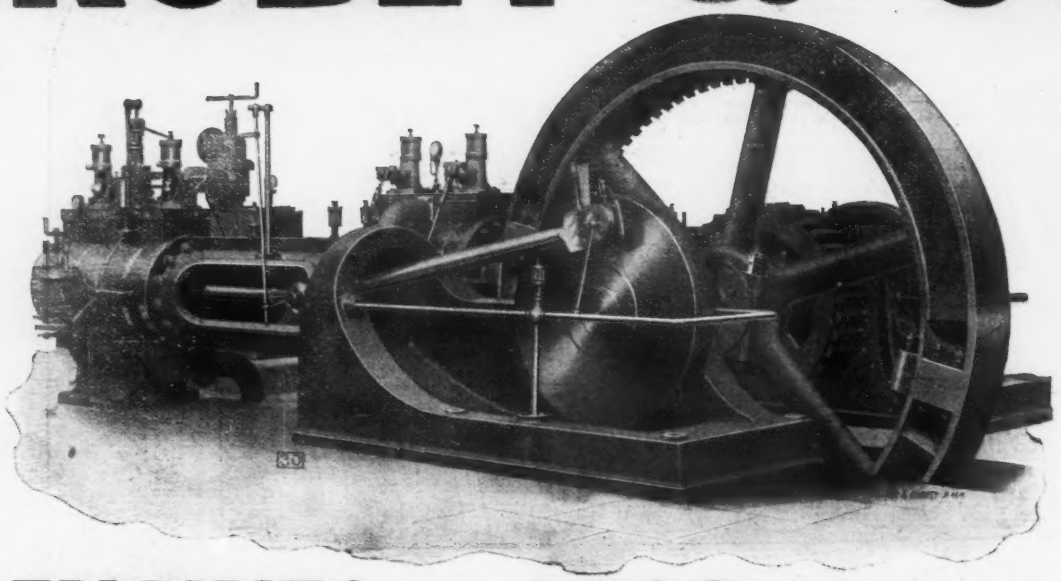

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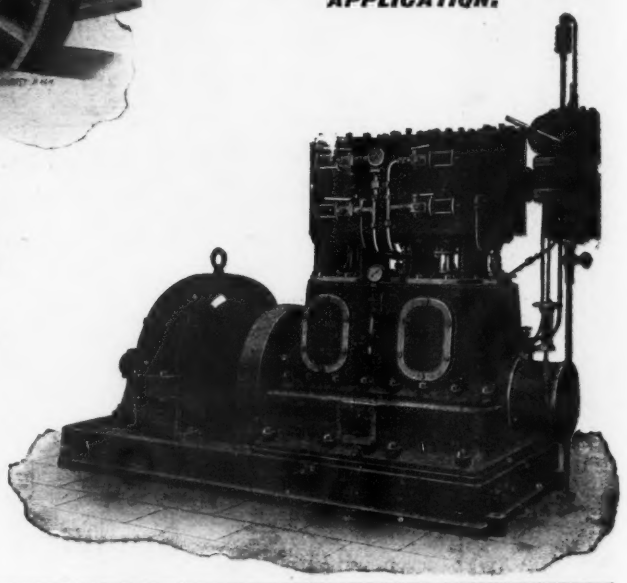

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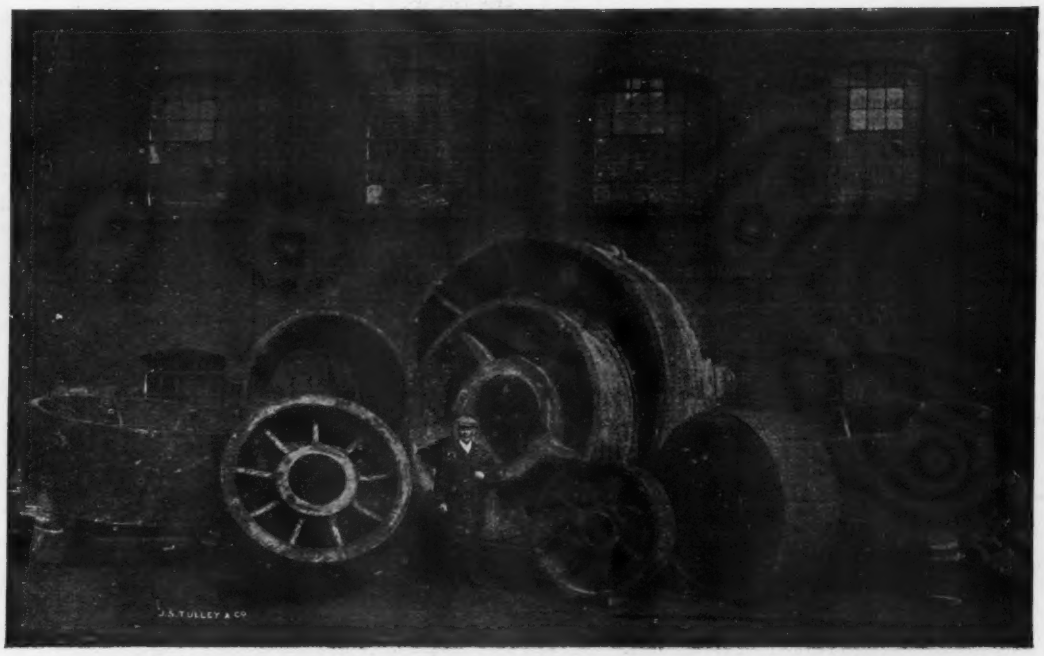

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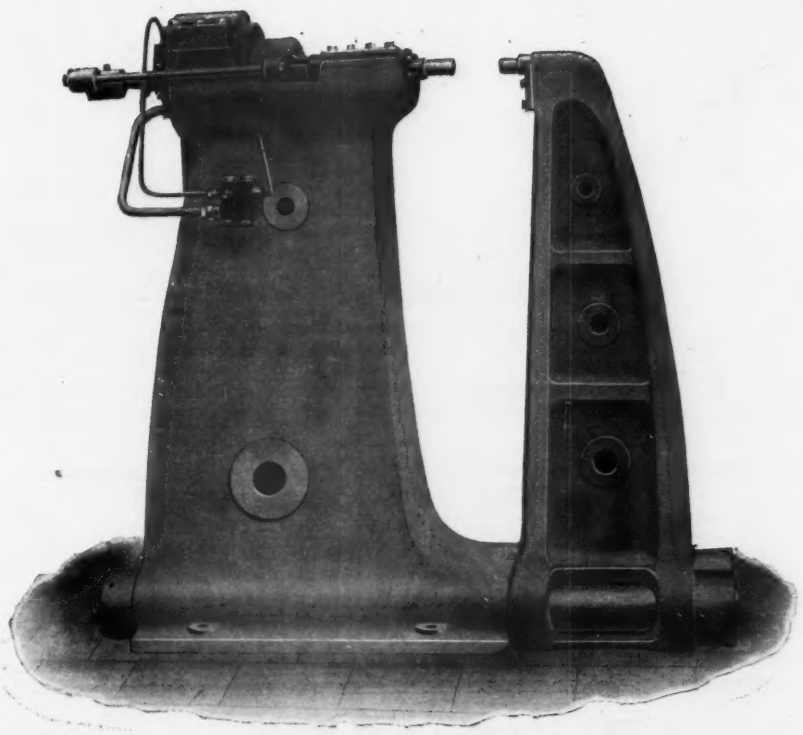

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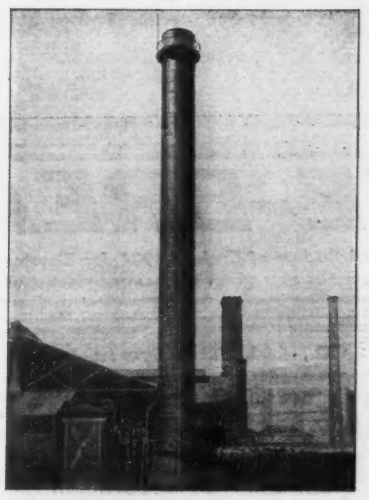

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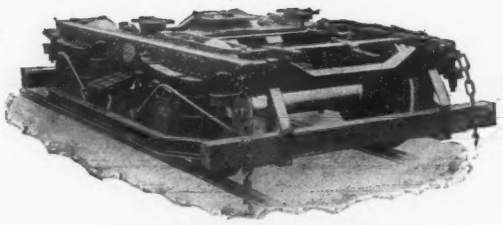

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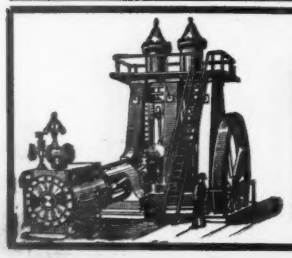

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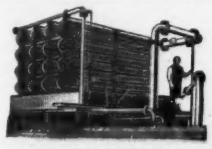

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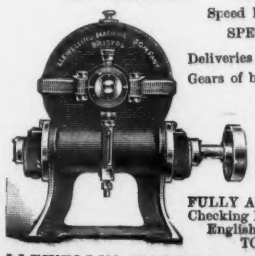

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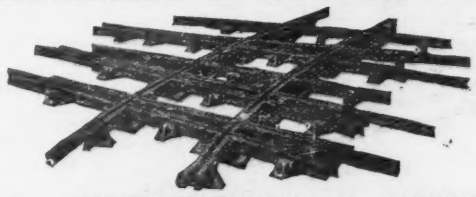

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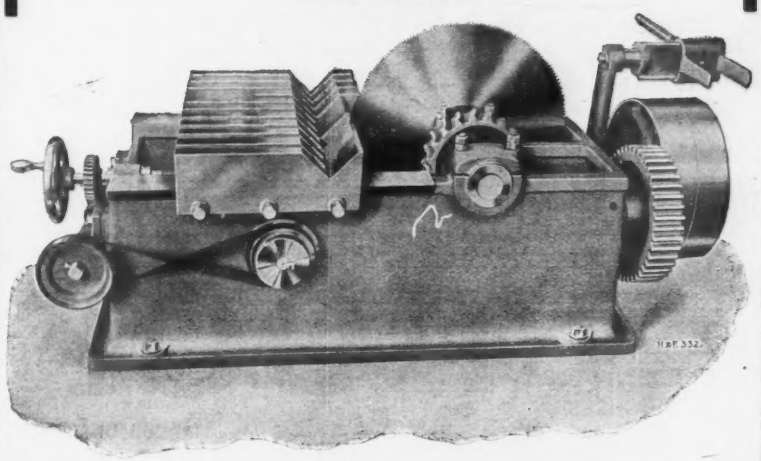

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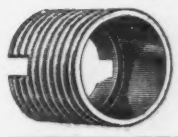

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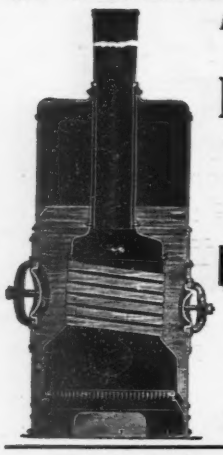

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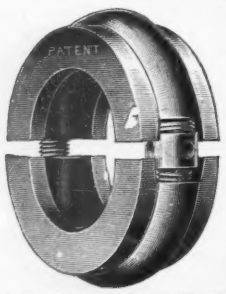

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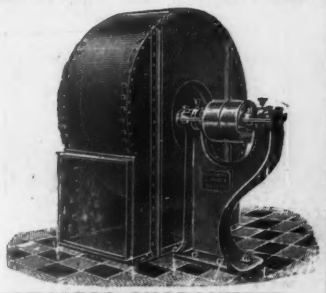

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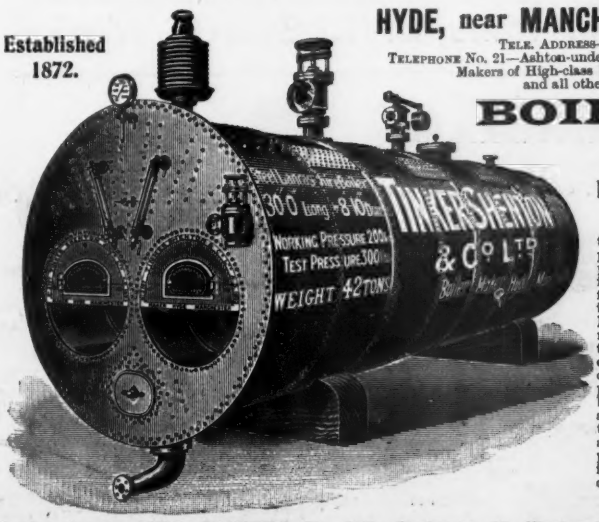

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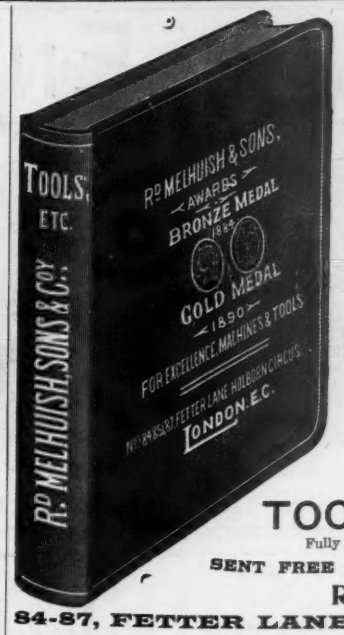

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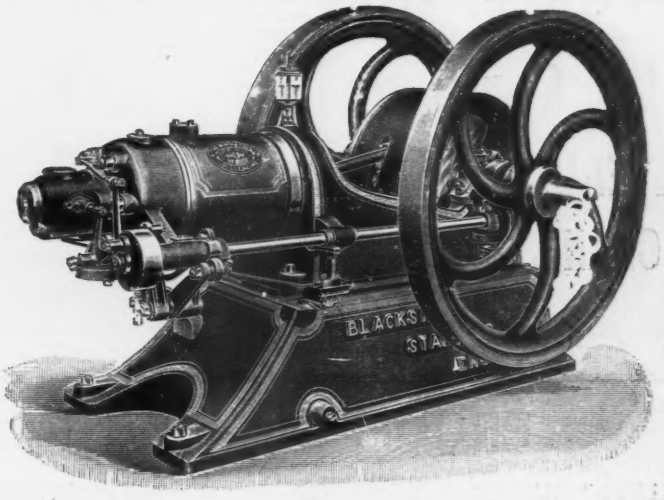

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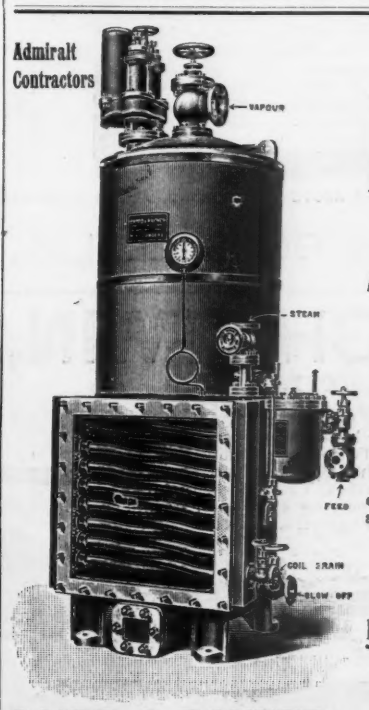

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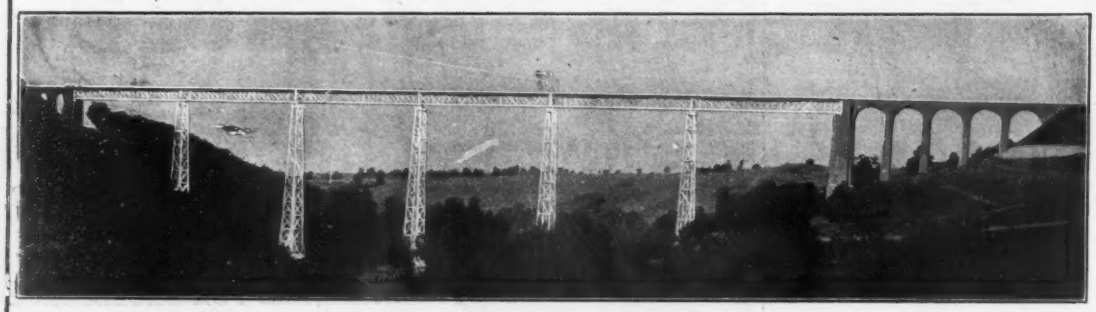

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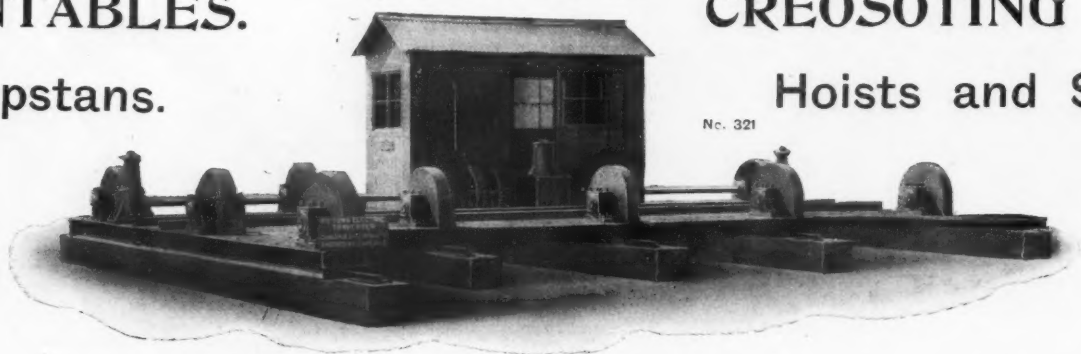

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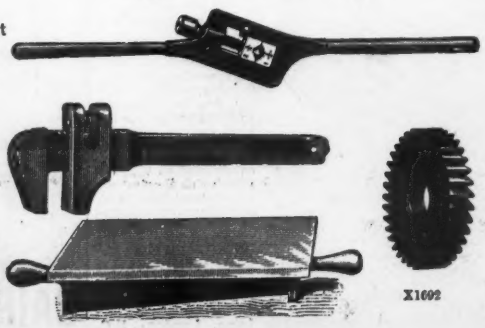

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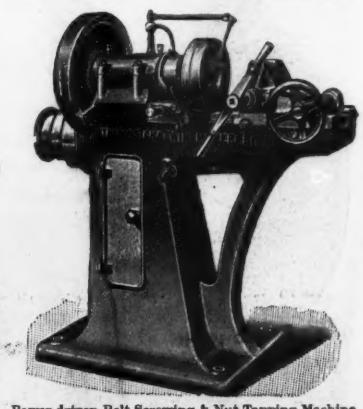

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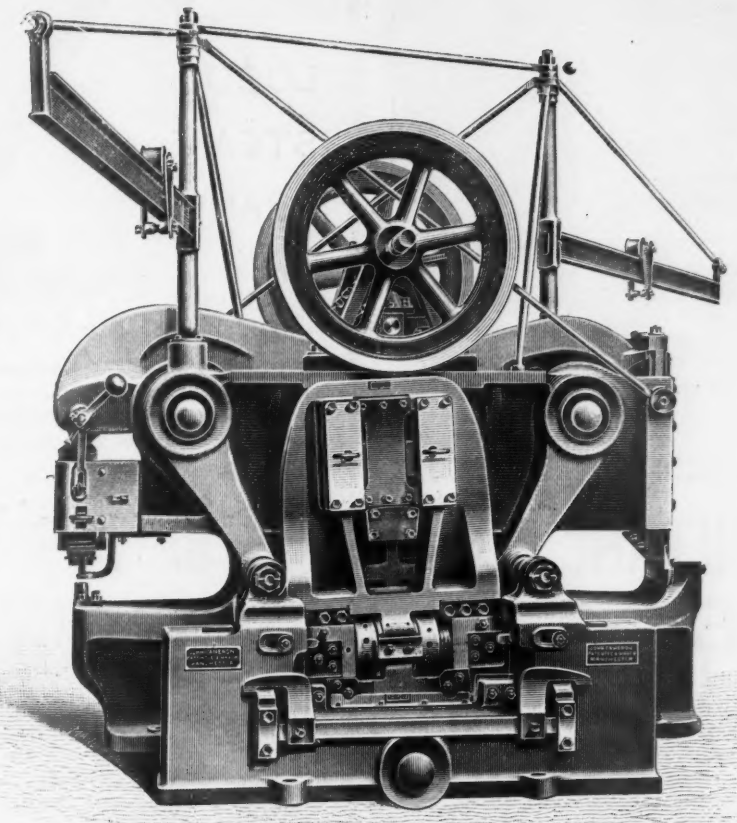

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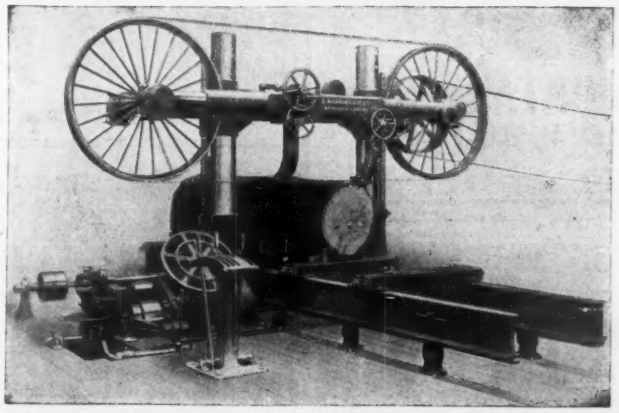

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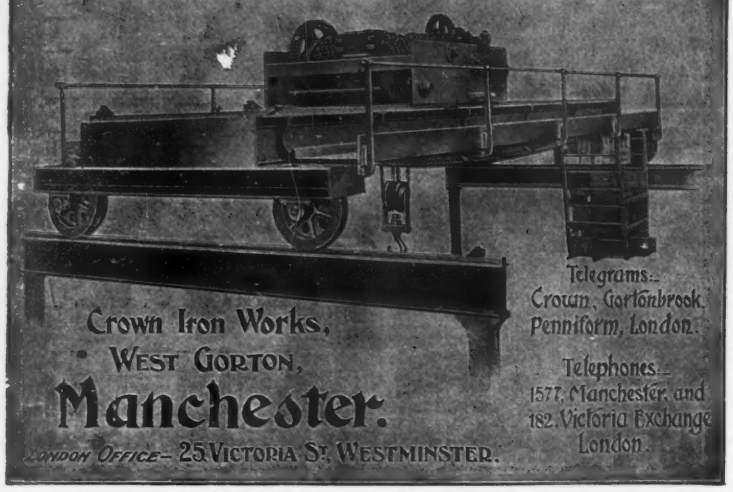

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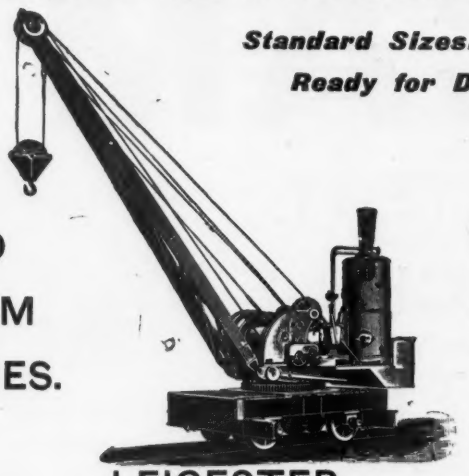

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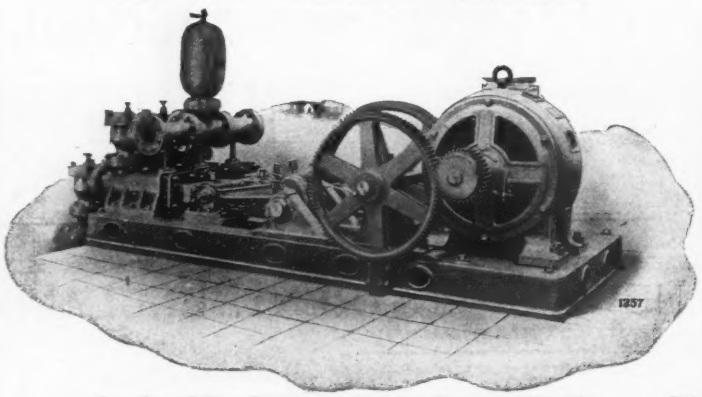

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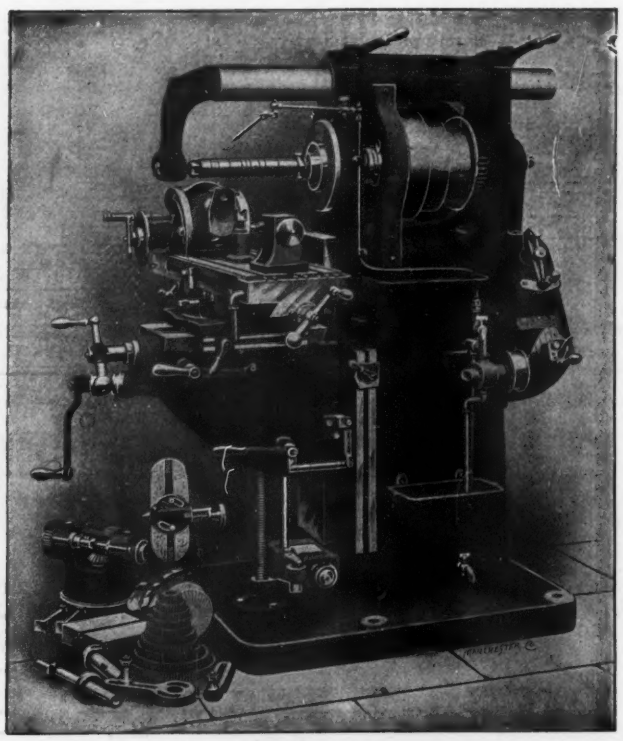

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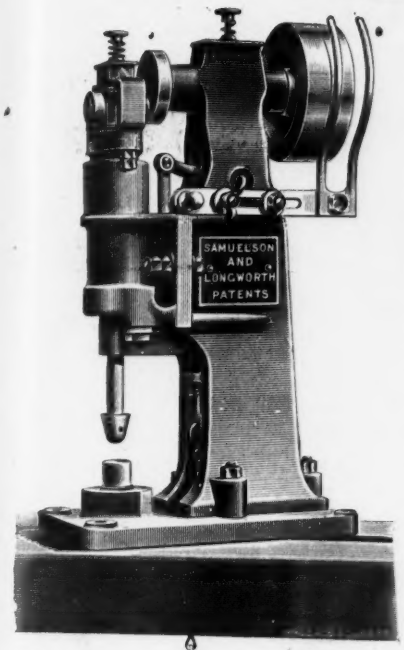

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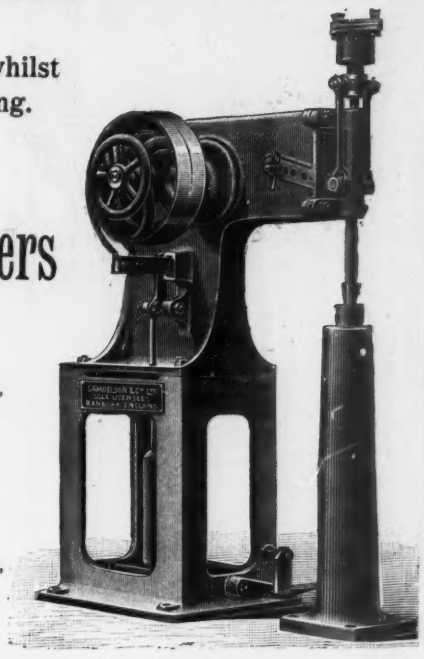

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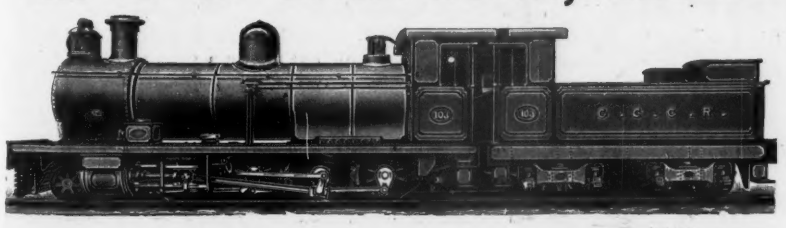

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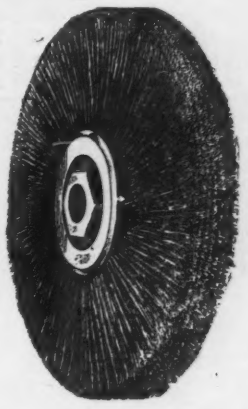

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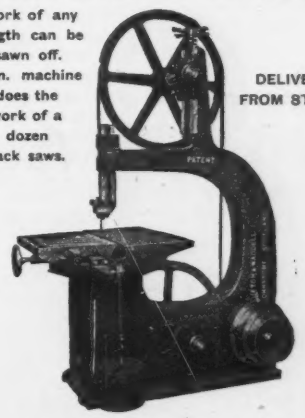

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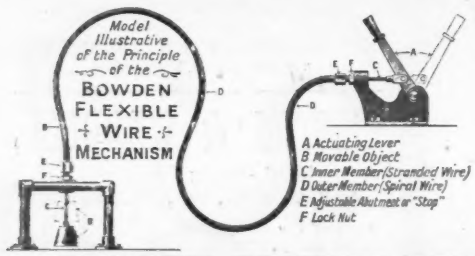
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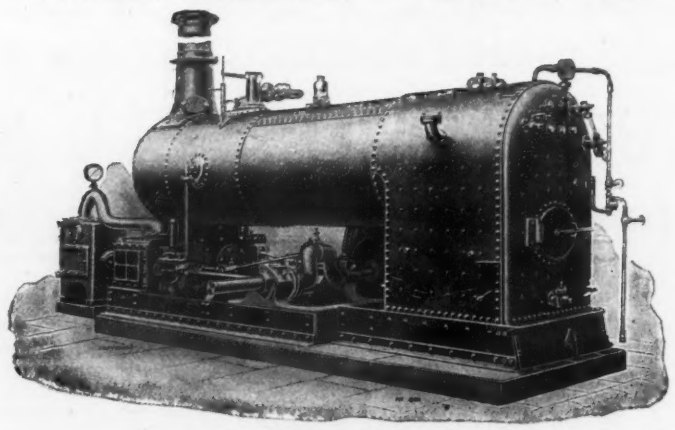

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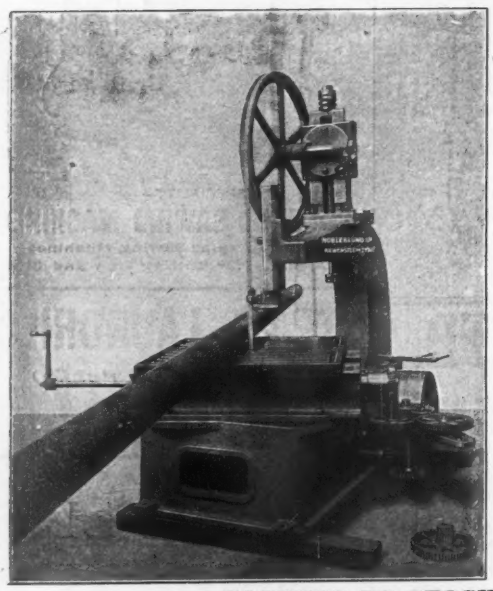

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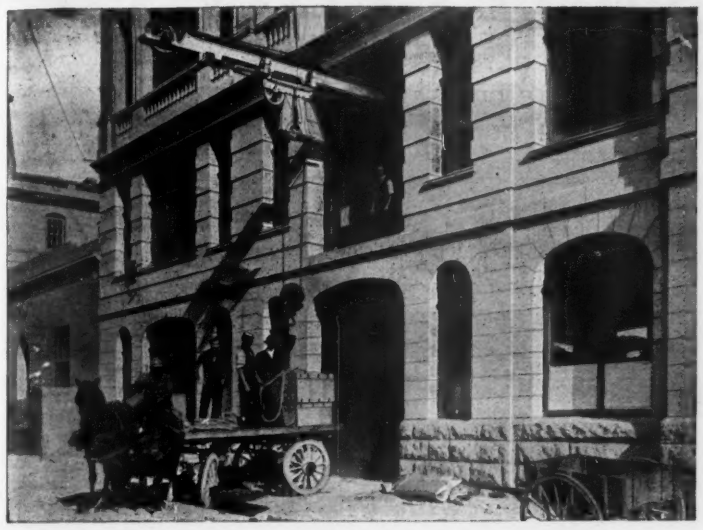

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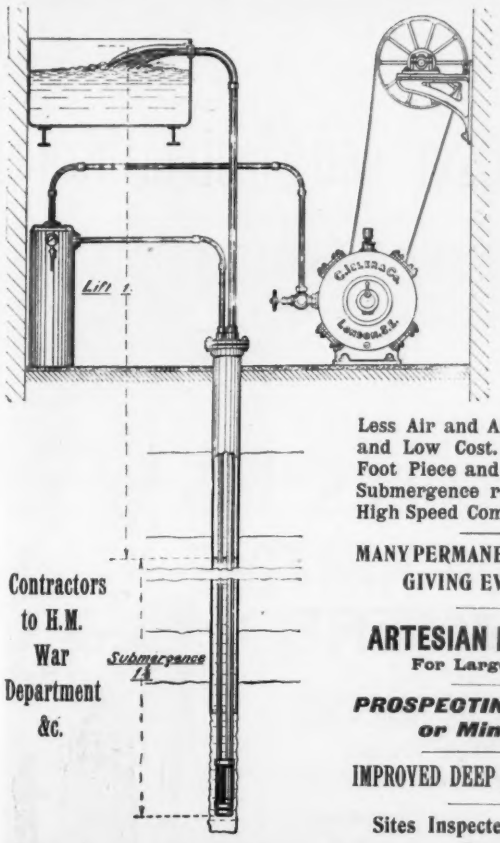

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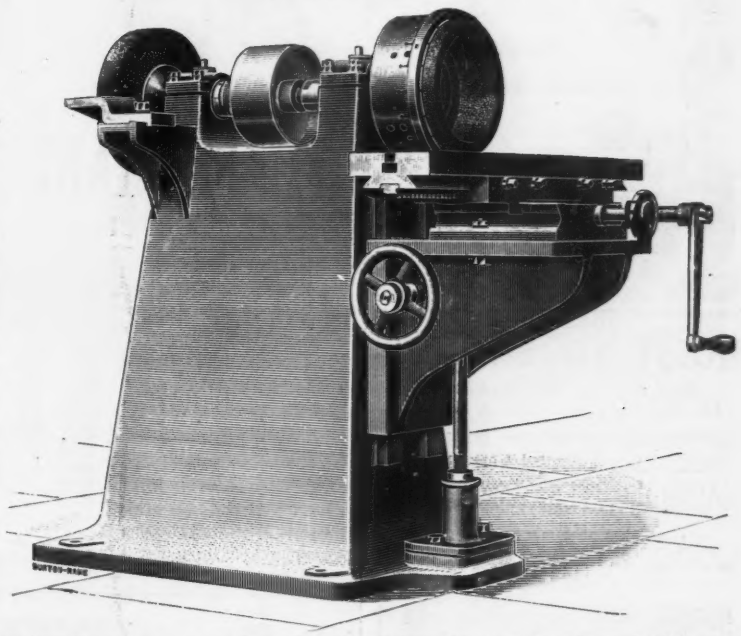

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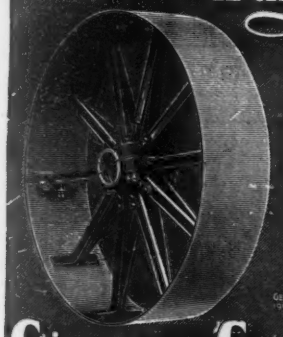

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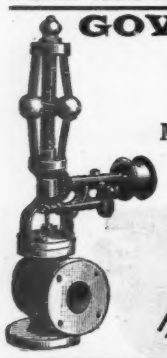

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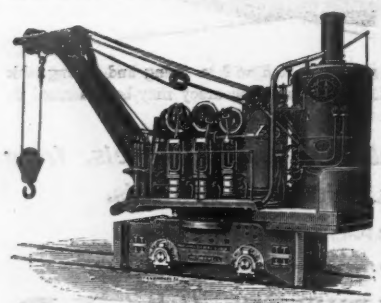

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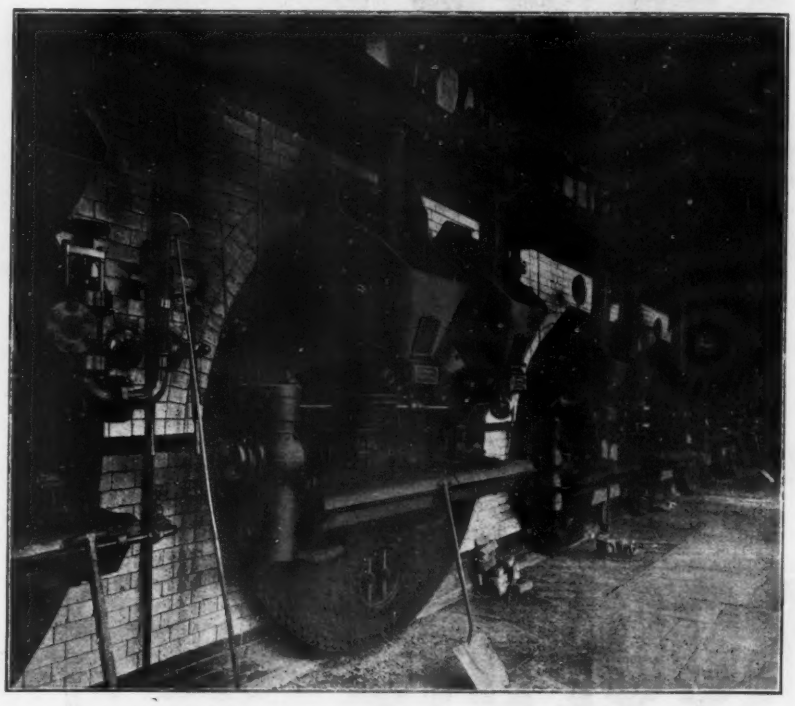

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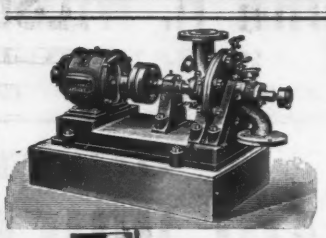

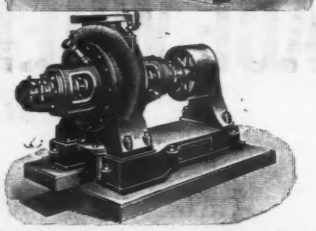

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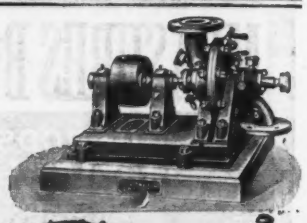

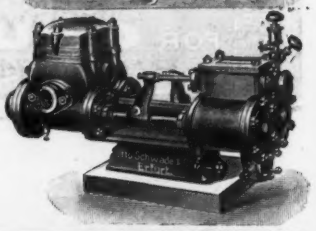

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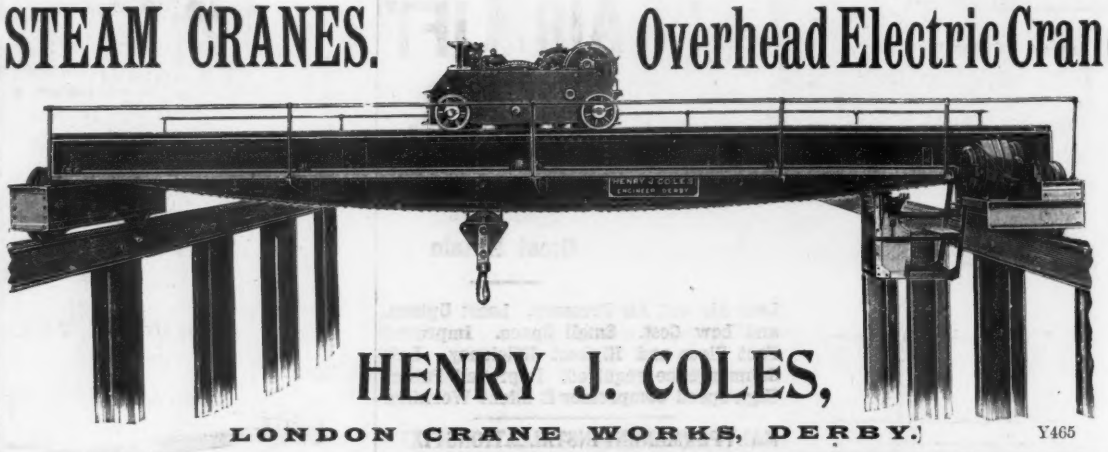

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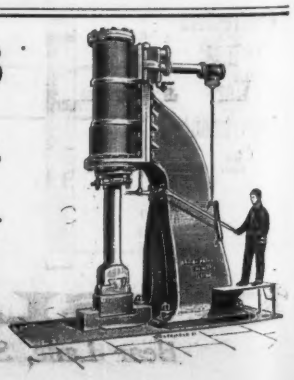

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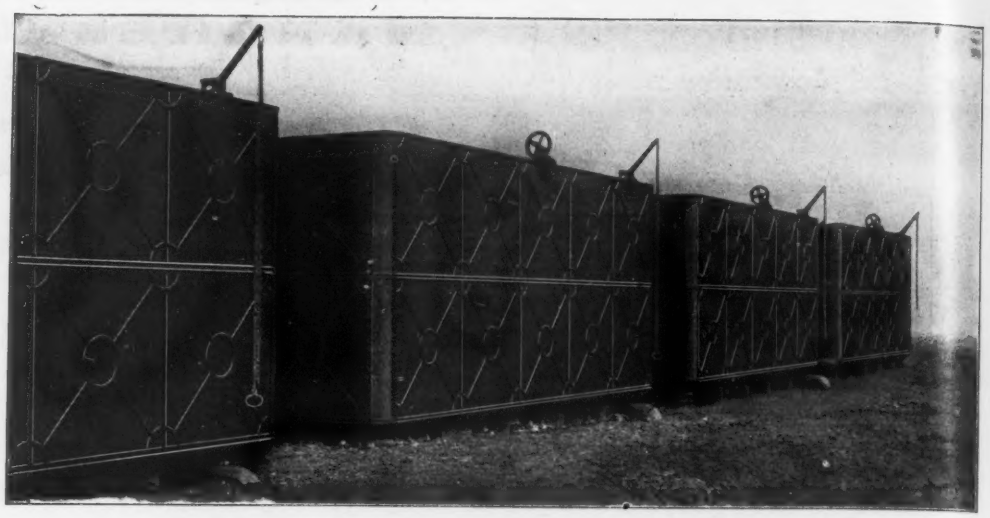

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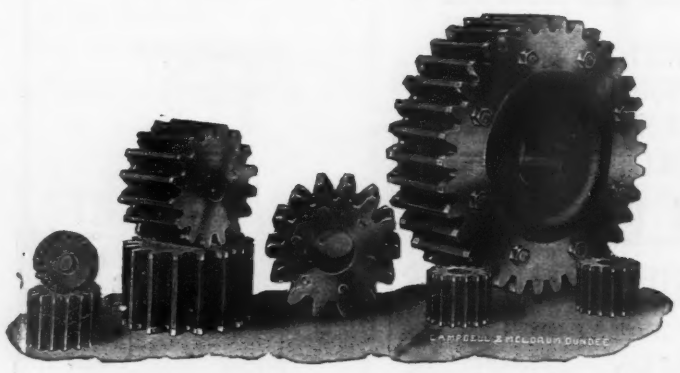

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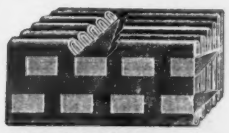

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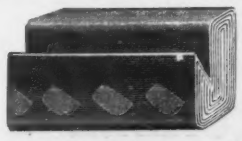

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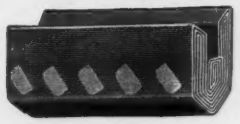

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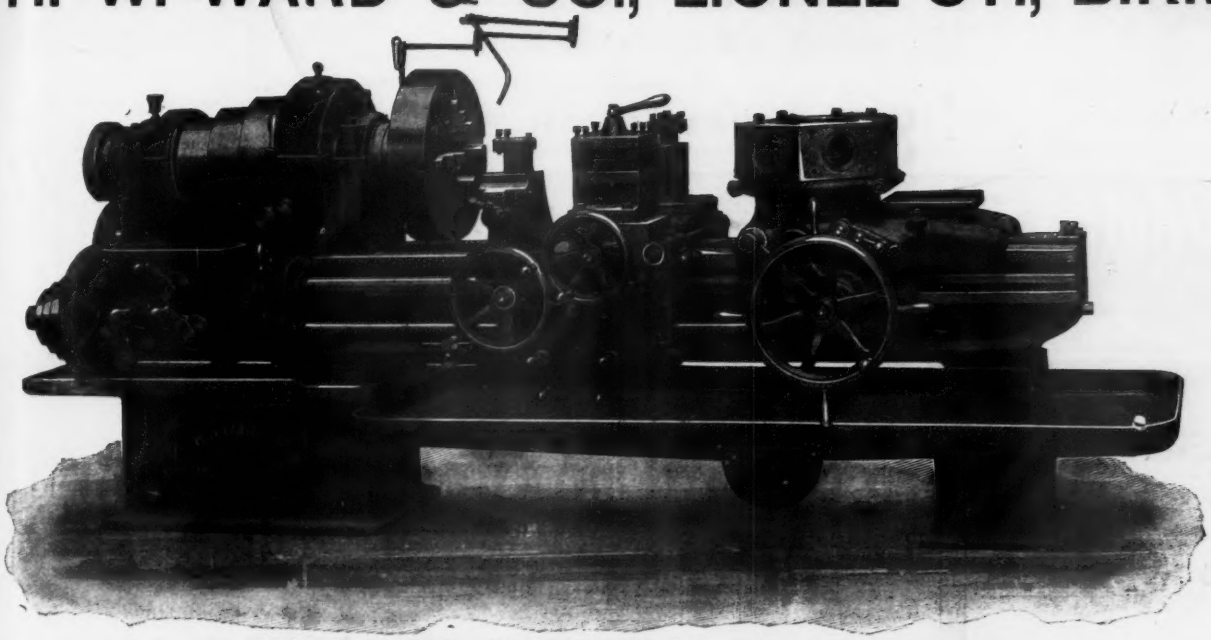

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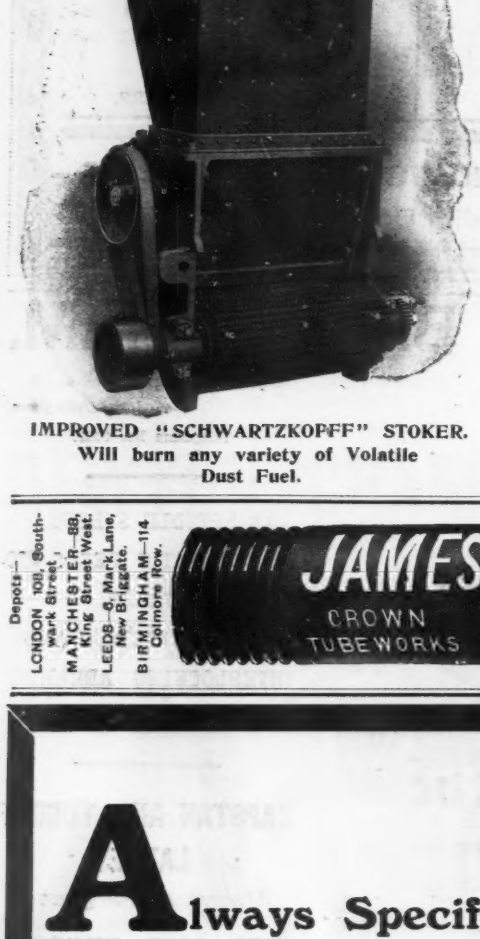

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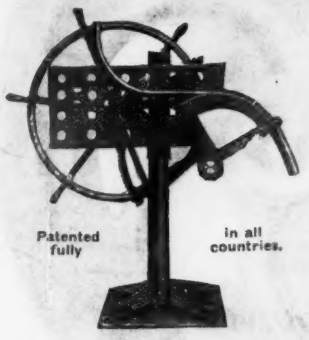

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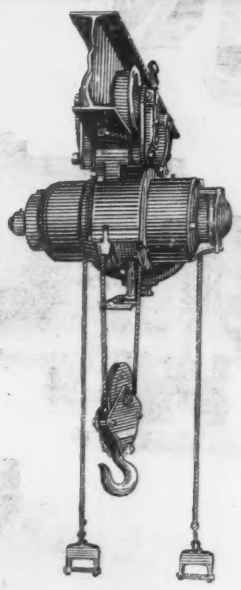

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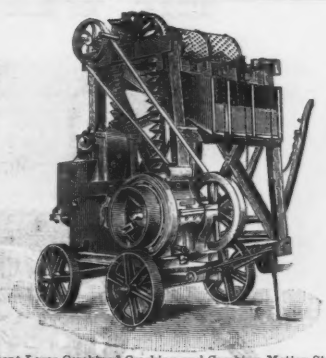

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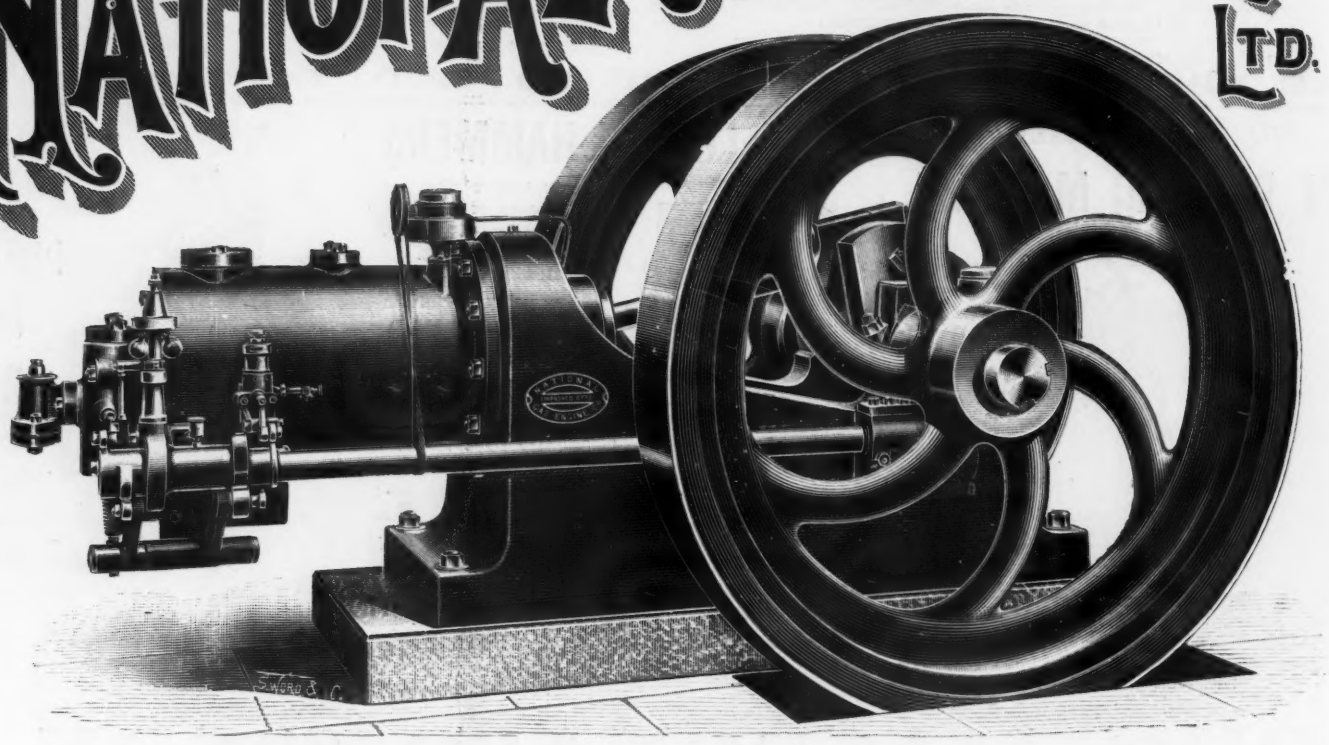

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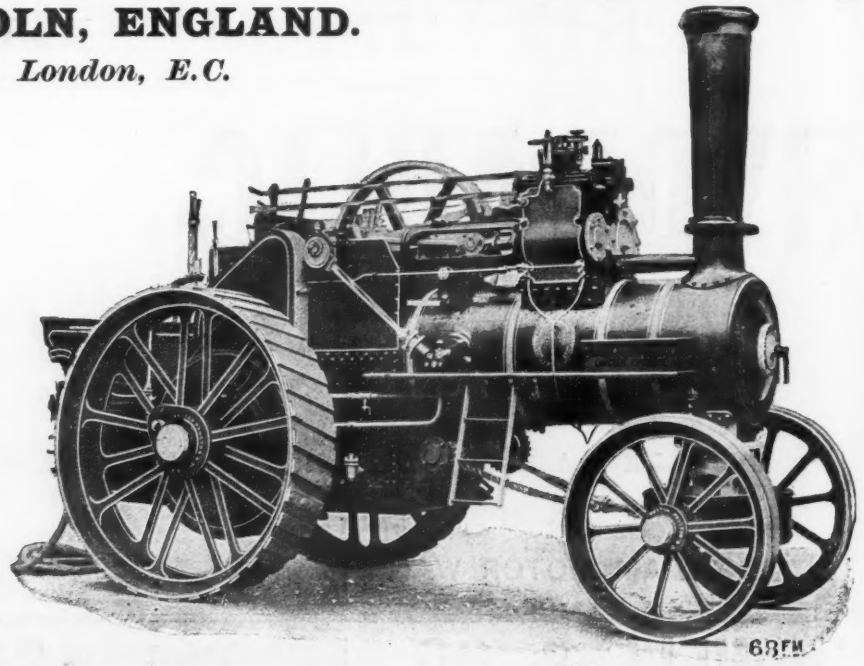

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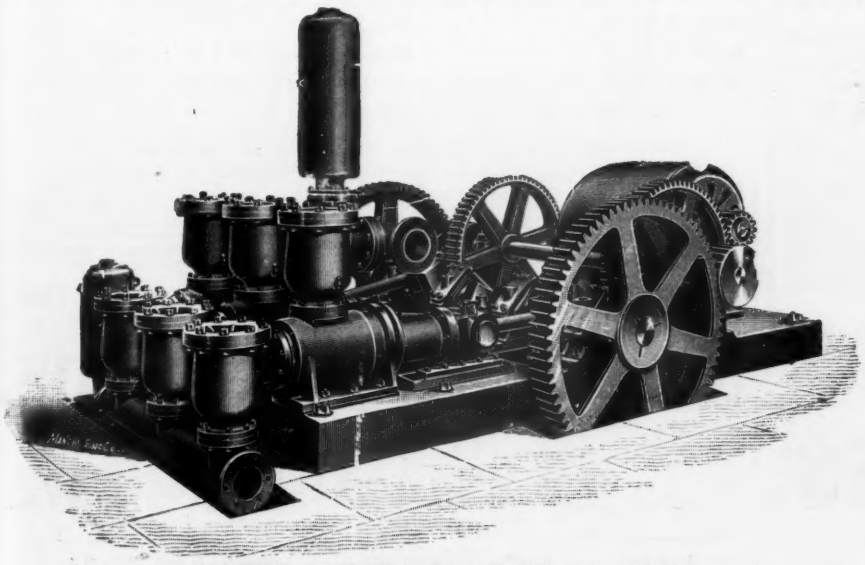

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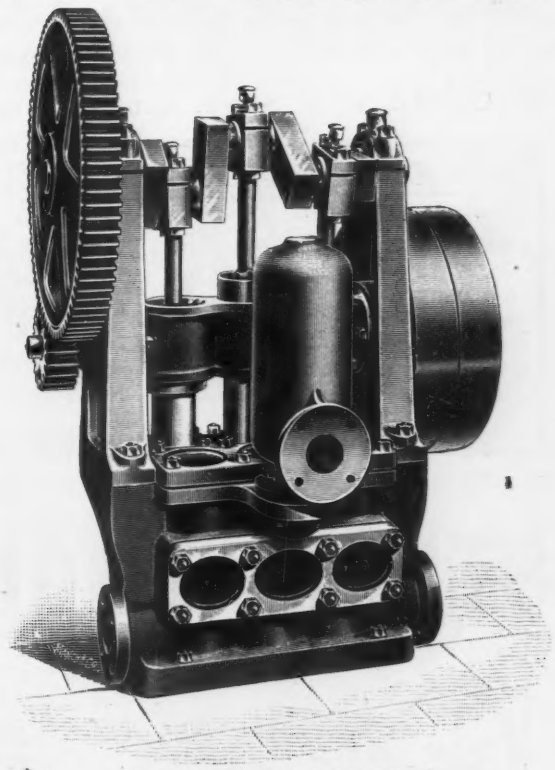

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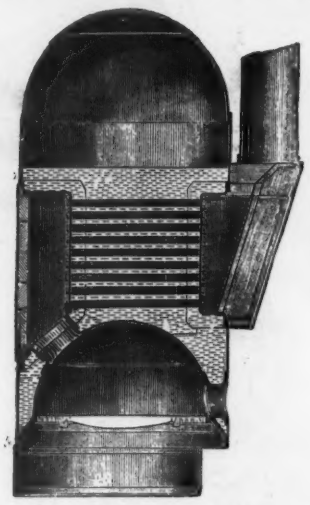

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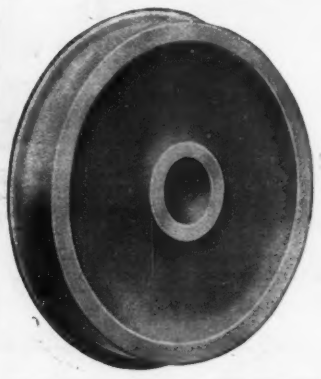

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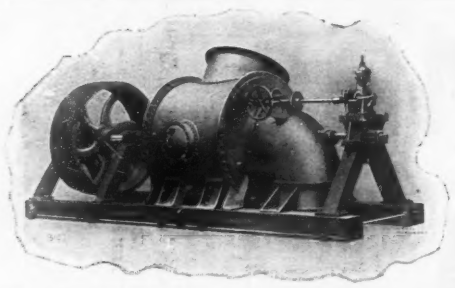

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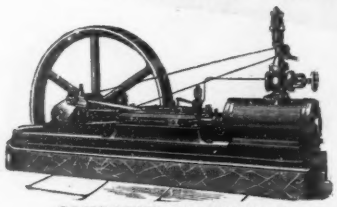

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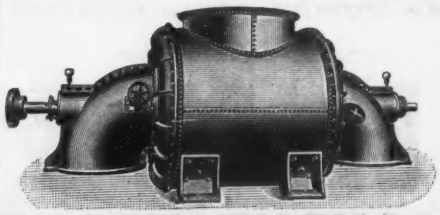

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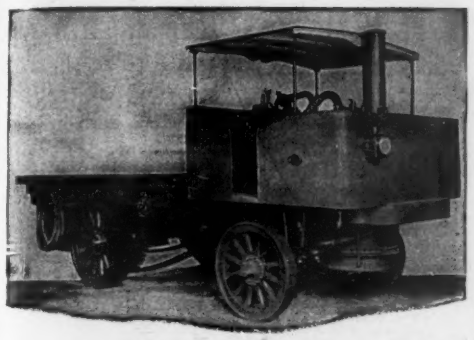

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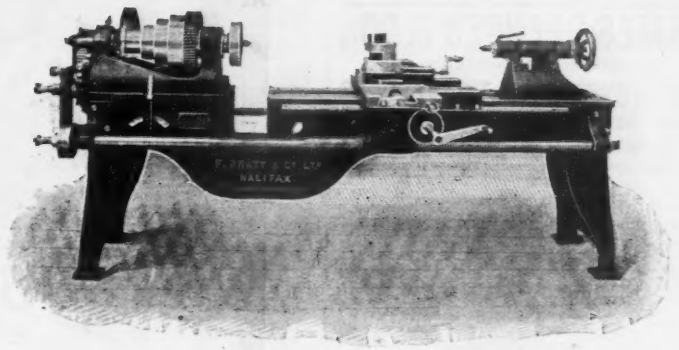

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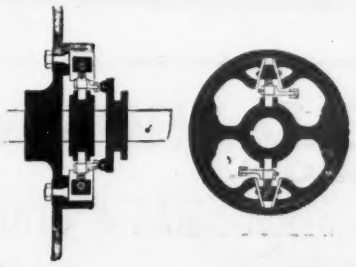

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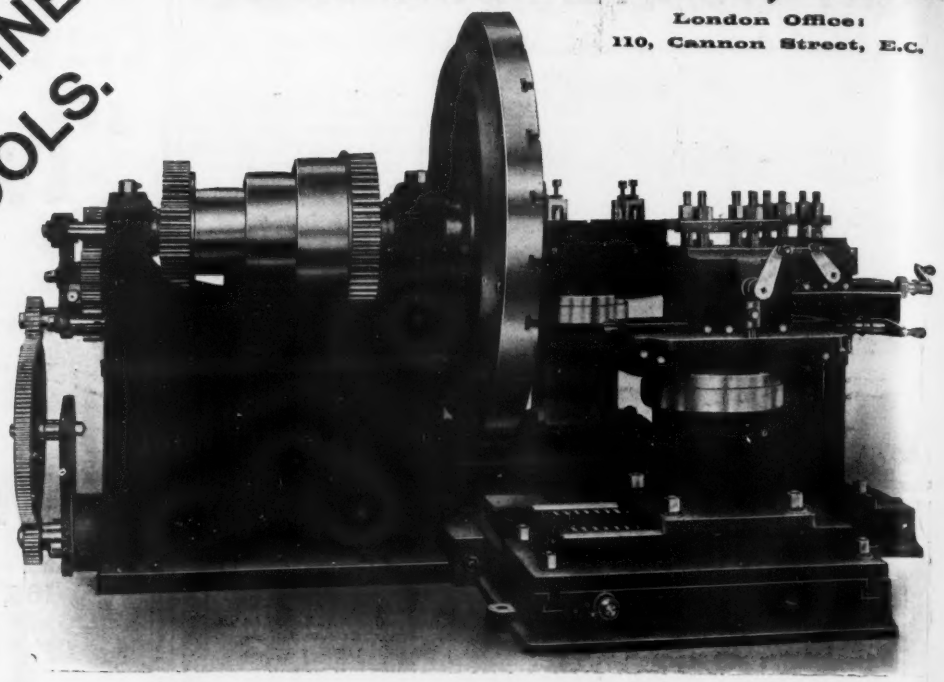

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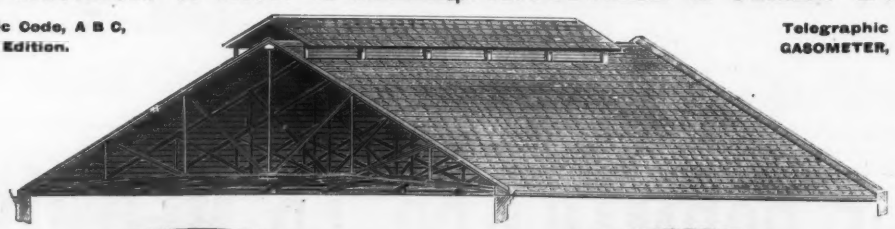

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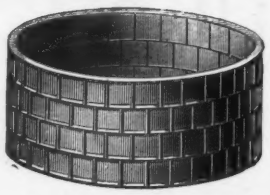

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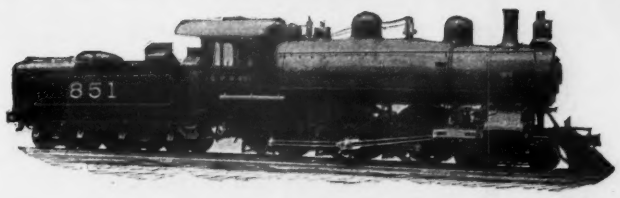

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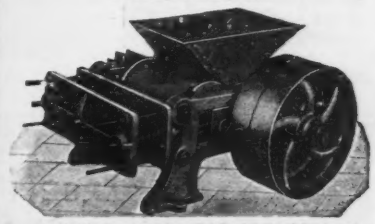

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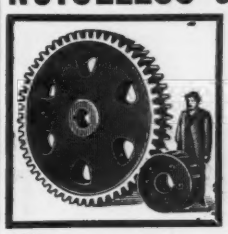

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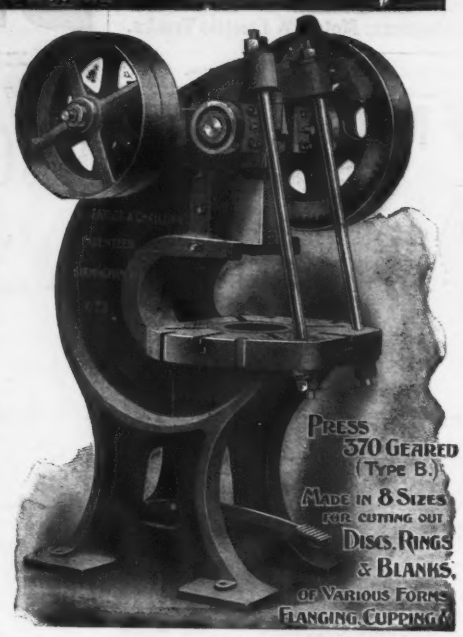

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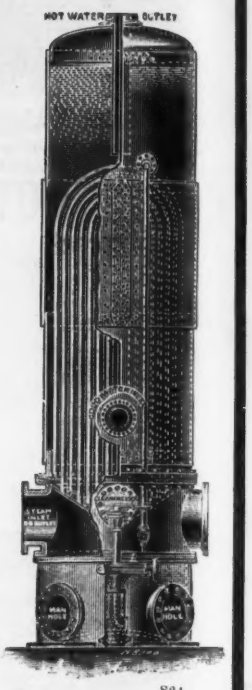

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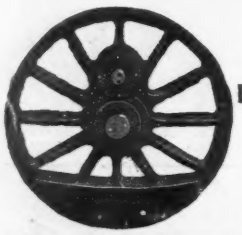

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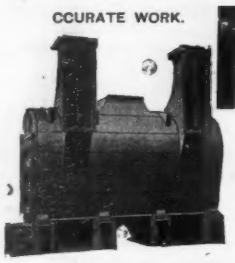

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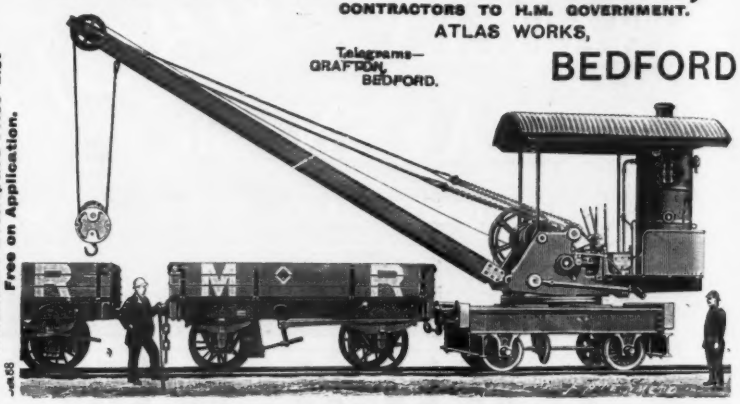

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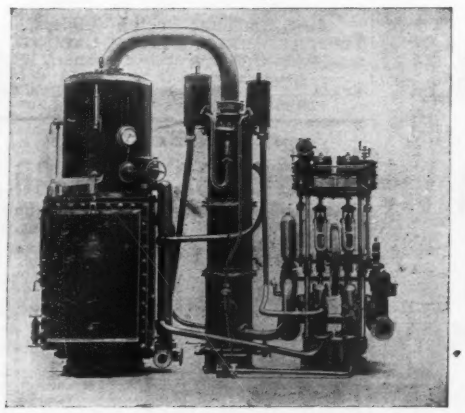

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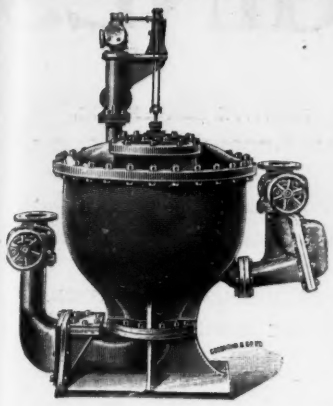

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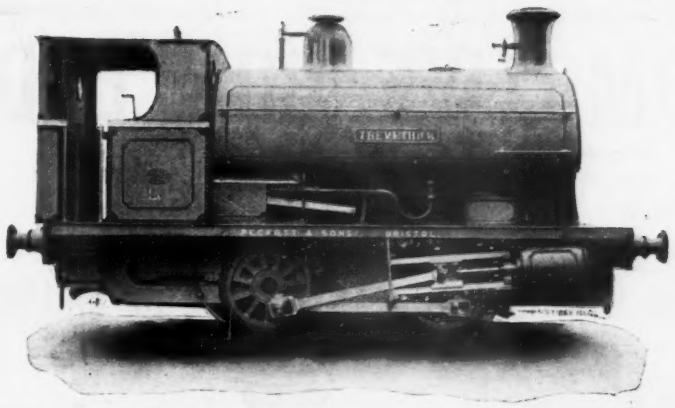

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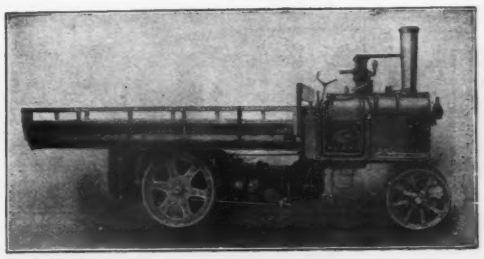

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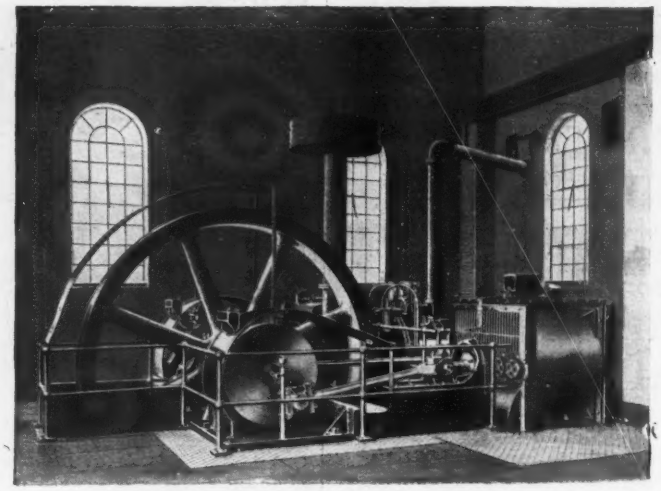

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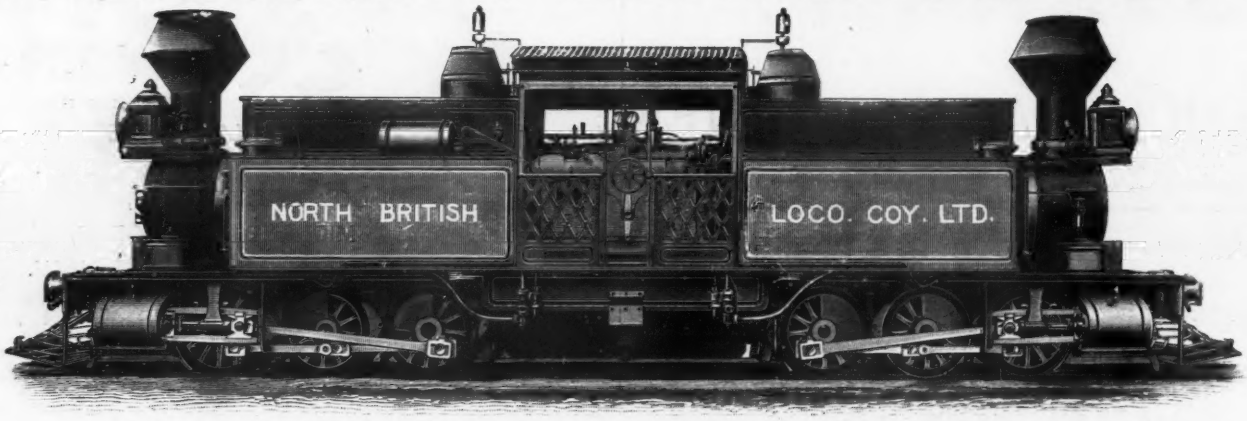

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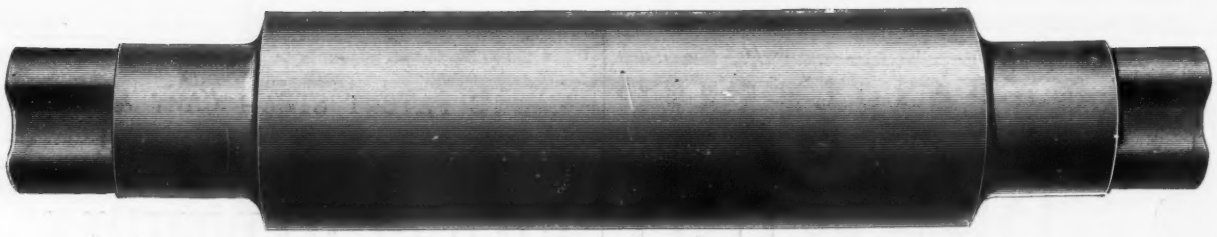

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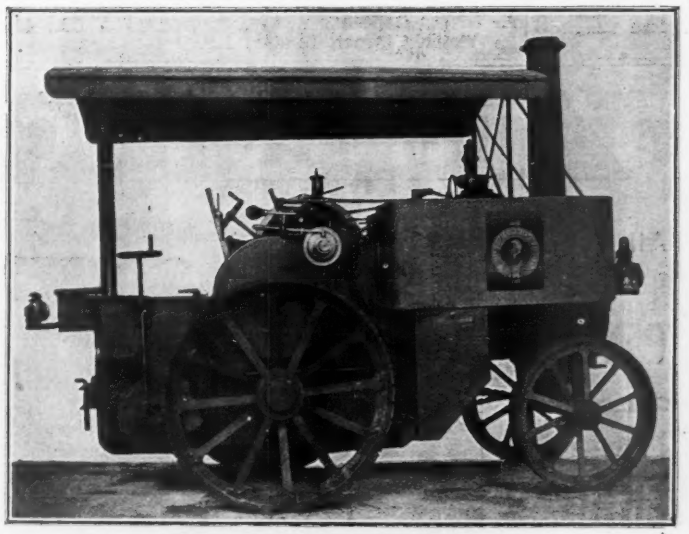

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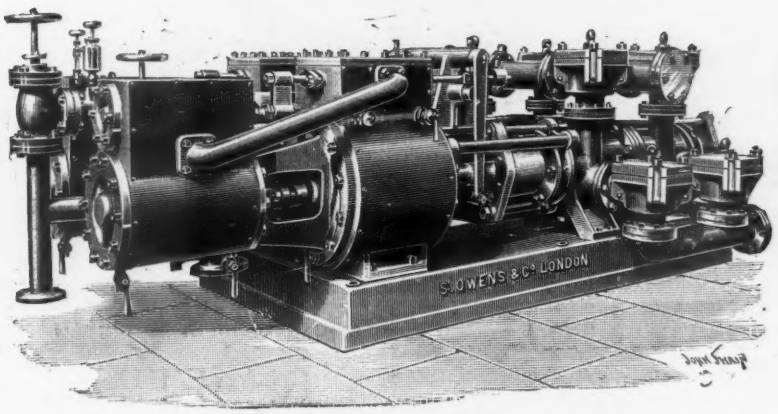

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Q527
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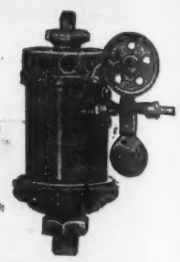

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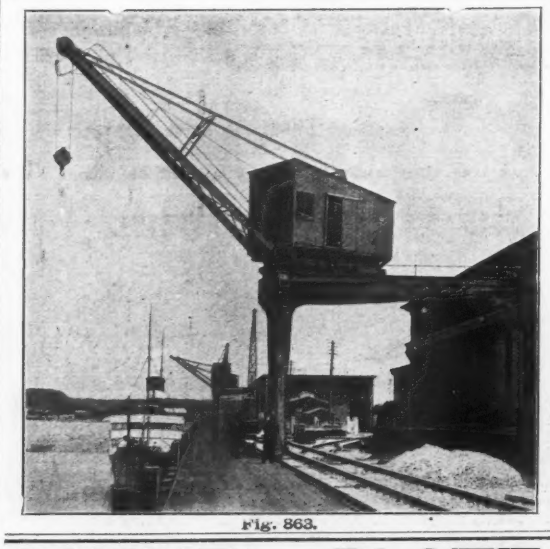
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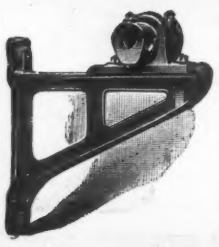

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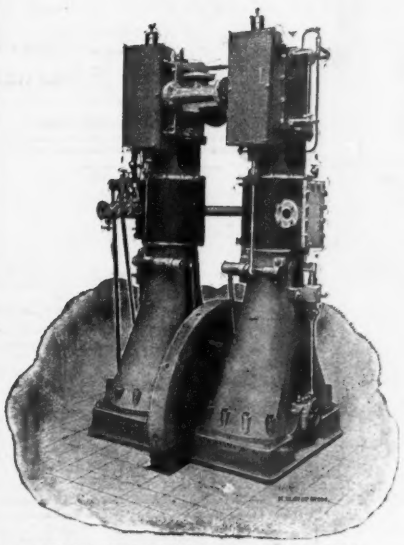

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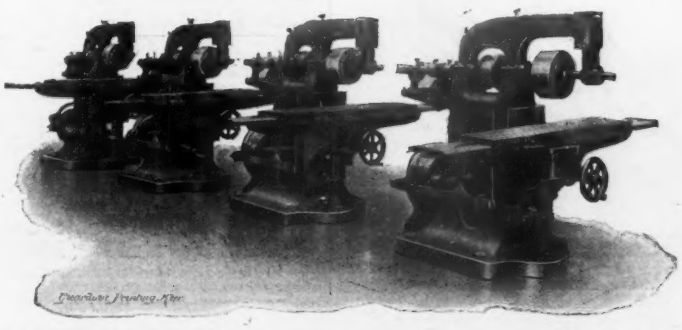

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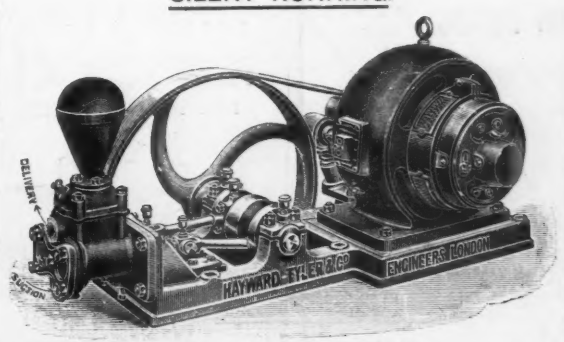

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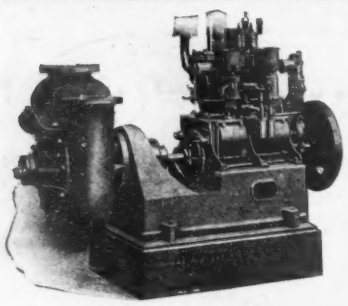

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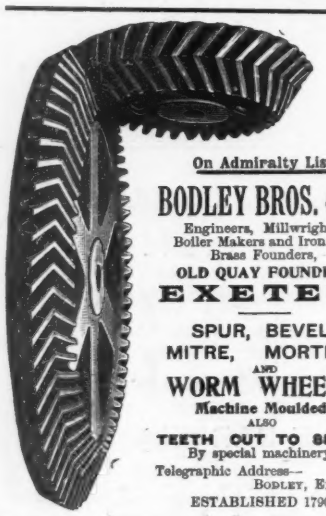

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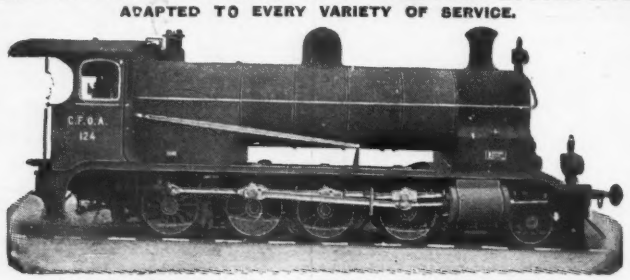

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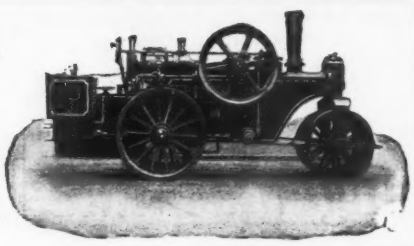

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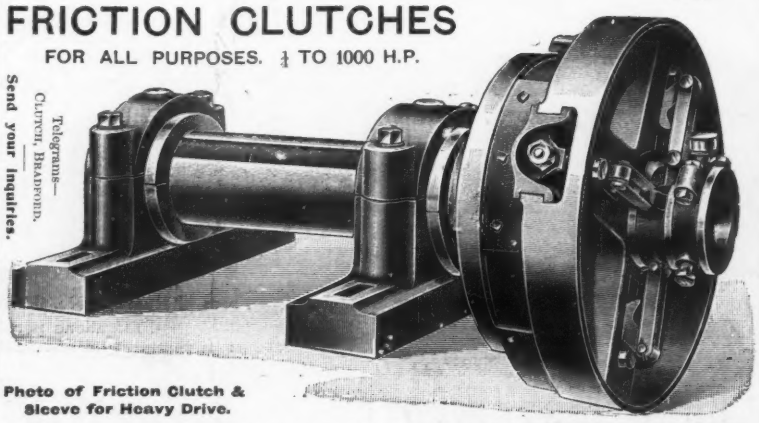

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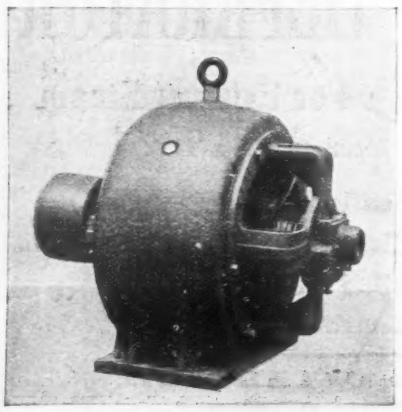

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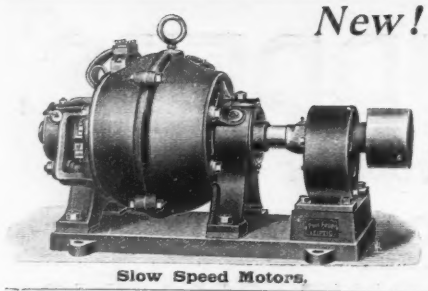

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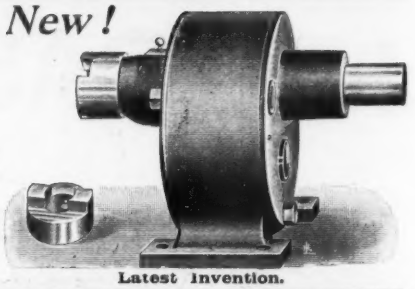

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Herbert, A., Ld
Lilleshall Co
Shaw, W., and Co
Tannett, Walker and Co., Ld

Cement:
Nelson, C., and Co.
West Kent Portland Cement Co

Centrifugals:
Pott, Cassels and Williamson

Chains:
Dale, William

Coal and Coke:
Newton, Chambers, & Co., Ld
Talk o'th Hill Colliery, Ld

Coal Cutting Machinery:
Chambers, Scott and Co

Collars, Split Grip:
Trier Brothers

Condensers:
Carrick and Wardale
Cole, Marchent & Morley, Ld
Craig, A. F., and Co., Ld
Edwards Air Pump Syndicate, Ld
Fawcett, Preston and Co., Ld
Fraser, D., and Sons
Körting Brothers, Ld
Ledward and Beckett, Ld
Mirrlees Watson Co., Ld
Storey, I., and Sons, Ld
Wheeler Condenser Co

Conveyors
Barry, Henry and Co., Ld
Conveyor and Elevator Co
Gilbert Little Co., Ld
Graham, Morton and Co
New Conveyor Co., Ld
Pott, Cassels and Williamson

Cooling Towers:
Balcke and Co
Körting Brothers, Ld

Couplers, Automatic:
Laycock, W. S., Ld

Cranes:
Bedford Engineering Co
Booth, Jos., & Bros. (Rodley)
Broadbent, T., and Sons
Chaplin, A., and Co
Clarke, Chapman and Co., Ld
Coles, H. J.
Cowans, Sheldon and Co., Ld
Craven Brothers, Ld
Fielding and Platt, Ld
Gibbins, R. C., and Co
Grafton and Co.
Grieve, J., and Co
Henderson, J. M., and Co.
Higginbottom and Mannock, Isles Ld
Jessop and Appleby Bros., Ld
Leeds Eng'g. & Hydraulic Co
Marshall, Fleming and Jack
Musker, C. and A., Ld
Ransomes and Rapier, Ld
Roger, R., and Co
Russell, G., and Co
Smith, T., and Sons (Rodley)
Taylor and Hubbard
Temperley Transporter Co
Wilson, J. H., and Co., Ld

Crucibles:
Doulton and Co., Ld

Destructors:
Horsfall Destructor Co., Ld
Meldrum Bros., Ld

Diving Apparatus:
Barnett and Foster
Siebe, Gorman and Co., Ld

Drafting Machines:
Herbert, A., Ld

Drawings, Tracings, &c.:
Hall, B. J., and Co
Messer and Thorpe

Dredge Plant:
Ferguson Brothers
Fleming and Ferguson, Ld
Priestman Bros., Ld
Royal Dutch Forge Co
Simons, W., and Co., Ld
Smulders, A. F.

Drop Forgings and Stampings:
Armstrong, Stevens and Son
Smith, T., and Sons, of Saltley

Drop Hammers:
Brett's Patent Lifter Co., Ld

Electricity:
Allen, W. H., Son & Co., Ld
Bellis and Morcom, Ld
Brit. Westinghouse Electric Co
Bruce Peebles and Co., Ld
Crompton and Co., Ld
Dick, Kerr and Co., Ld
Electric Ordnance and Accessories Co., Ld
Fowler, J., and Co., Ld
Gimson and Co., Ld
Hall, J. P., and Co
Hartnell, W., and Co., Ld
India-rubber, Gutta Percha & Telegraph Works Co., Ld
Industrial Engineering Co
Johnson and Phillips
Laurence, Scott and Co., Ld
Parker Thomas, Ld

Electricity *(continued)*
Royce Limited
Scott and Mountain, Ld
Tangye Tool and Electric Co
Veritys Limited

Elevators:
Conveyor and Elevator Co
Gilbert Little Co., Ld
Graham, Morton and Co
New Conveyor Co., Ld

Emery, Emery Wheels, &c.:
Carborundum Co
London Emery Works Co
Luke and Spencer, Ld
Mitchell's Emery Wheel Co
Oakey, J., and Sons
Rowland, B. R., and Co
Sterne, L., and Co., Ld

Engine & Boiler Fittings, &c.:
Bailey, W. H., and Co., Ld
Bell's Asbestos Co., Ld
Hulburd Engineering Co
Klinger, R., and Co

Evaporators:
Blair, Campbell & McLean, Ld.
Caird and Rayner
Liverpool Engineering and Condenser Co., Ld
Normandy's Fresh Water Co
Royles Limited

Excavators:
Priestman Bros., Ld
Whitaker Brothers, Ld
Wilson, J. H., and Co., Ld

Expanded Metal:
New Expanded Metal Co., Ld

Explosives:
New Explosives Co., Ld

Fans and Turbines:
Böving, J. Orten
Buffalo Forge Co
Davidson and Co., Ld
Escher, Wyss and Co., Ld
Gilkes, G., and Co., Ld
Gunther, W., and Sons
Heenan and Froude, Ld
Keith and Blackman Co., Ld
Musgrave and Co., Ld
Parsons, C. A., and Co
Parsons Steam Turbine Co
Pitman, P.
Russell, S., and Sons
Thwaites Brothers, Ld
Waddle Patent Fan and Engineering Co

Feed-water Heaters
Holden and Brooke, Ld
Royles Limited
Weir, G. and J., Ld
Wheeler Condenser and Engineering Co
Wright, Jos., and Co

Fencing:
Baylis, Jones and Baylis, Ld
Rowell, D., and Co

Filters, Waste Oil:
Wells, A. C., and Co

Fireproof Construction:
British Uralite Co., Ld
Liverpool Hennebique Ferro-Concrete Contracting Co
Trussed Concrete Steel Co

Flexible Shafts:
Wicksteed, C., and Co

Flour Mill Machinery
Turner, E. R. and F.

Forced Draught:
Granger, W. A.
Horsfall Destructor Co., Ld
Howden, J., and Co

Forgings:
Cammell Laird and Co., Ld
Clarke's Crank and Forge Co
Darlington Forge Co., Ld
Grantham Boiler & Crank Co
Ince Forge Co., Ld
Mills, Exors. of J.
Phillips, J., and Co
Rollason, A., and Sons

Foundry Requisites:
Jackman, J. W., and Co

Friction Clutches:
Bagshaw, J., and Sons
Durham, Churchill & Co., Ld
Edmeston, A., and Sons
Longbothann, R. H., and Co
Wigglesworth, F., and Co., Ld

Fuel Economisers:
Clay Cross Co

Furnaces:
Brown, J., and Co., Ld
Butterley Co., Ld
Deighton's Flue and Tube Co
Leeds Forge Co., Ld
Meldrum Brothers, Ld

Fusible Plugs:
National Boiler and General Insurance Co

Gas:
Dowson Economic Gas Co., Ld

Gas Engines:
British Westinghouse Electric and Manufacturing Co., Ld
Cail Engineering Co
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Daniels, T. H. and J., Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons, Ld
Grice, W., and Sons
Hardy and Padmore, Ld
Haslam Foundry & Eng'g Co., Ld
Hornsby, R., and Sons, Ld
National Gas Engine Co., Ld
Pierson, J. and O. G.
Pollock, Whyte and Waddell
Premier Gas Engine Co., Ld
Robey and Co., Ld
Rodger, A., and Co.
Tangyes Limited

Gauge Glasses:
Butterworth Bros., Ld
Guilbert-Martin
Moncrieff, J.
Tomey, J., and Sons, Ld

Gauge Glass Protectors:
Hulburd Engineering Co

Gauges:
Klinger, R., and Co
Negretti and Zambra
Phillips, J. W. and C. J.
Schaffer and Budenberg, Ld

Gear Cutting:
Brown, D., and Sons, Ld

Gearing:
Ah Ad.
Bodley Brothers and Co
Bowden Patents Syndicate, Ld
Citroen, Hinstin and Co
Harpers Limited
Heuer, P.
Reid Gear Co

Glass:
Pilkington Bros., Ld

Governors:
Pollock, MacNab & Highgate
Storey, I., and Sons, Ld

Grain Cleaning Machinery:
Boby, R., Ld

Graphite:
Dixon Crucible Co

Grinding Machinery
Bradley Pulveriser Co
Hall, J. S., and Co., Ld
Hardy Patent Pick Co, Ld
Phillips, J. W. and C. J.
Smedley Bros., Ld

Grisol Paint:
Lefranc and Co

Hammers:
Carron Company
Davis and Primrose
Massey, B. and S.
Piercy and Co
Player, W. and J.
Pollock, McNab & Highgate
Ross, R. G., and Son
Thwaites Bros., Ld

Handles:
Burley and Son, Ld

Harbour Plant:
Stothert and Pitt, Ld

Haulage Gear:
Carrick and Wardale
Tickle Bros.

Heating Apparatus:
Buffalo Forge Co
Körting Brothers, Ld
Smith, Howard and Co

Hose:
Merryweather and Sons, Ld
Moseley, D., and Sons, Ld

Hydraulic Leathers:
Ahlers, A.
Fleming, Birkby and Goodall
Rose, Downs & Thompson, Ld

Hydraulic Machinery:
Abbot, J., and Co., Ld
Bailey, W. H., and Co., Ld
Berry, H., and Co., Ld
Fawcett, Preston and Co., Ld
Fielding and Platt, Ld
Holt and Willetts
Leeds Engineering and Hydraulic Co
Musgrave Bros.
Musker, C. and A., Ld
Rice and Co., Ld
Smith, Hugh, and Co
Tannett, Walker and Co., Ld

Hydro-extractors:
Broadbent, T., and Sons
Manlove, Alliott and Co

India-rubber, &c.:
India-rubber, Gutta Percha & Telegraph Works Co., Ld
Moseley, D., and Sons, Ld

Indicators:
Crosby Steam Gage & Valve Co

Injectors & Ejectors
Davies and Metcalfe, Ld
Green and Fenwick, Ld
Gresham and Craven, Ld
Holden and Brooke, Ld
Klinger, R., and Co
Wilcox, W. H., and Co., Ld

Inks, Drawing:
Higgins and Co

Inspecting Engineer
Price, J.

Insurance:
Railway Passengers Assurance Corporation
Vulcan Boiler Insurance Co

Iron and Steel Works Plant:
Akrill, C., and Co., Ld
Head, Wrightson and Co., Ld
Jones, George, Ld
Lowca Engineering Co., Ld
Perry, T., and Son, Ld

Iron Buildings and Roofs:
Ash, J., and Son
Ashmore, Benson, Pease & Co
Barrowfield Ironworks, Ld
Braby, F., and Co
Bruce and Still, Ld
Clyde Structural Iron Co., Ld
Darlington Construction Co
Grover and Co., Ld
Handyside and Co., Ld
Hill and Smith
Lysaght, J., Ld
Main, A. and J., and Co
Morton, F., and Co., Ld
Piggott, T., and Co., Ld
Rowell, D., and Co
Walker Brothers, Ld

Jointing:
Bagshawe and Co
Klinger, R., and Co
Dixon Crucible Co
London Engineering Co., Ld
Moor and Co
Walker, J., and Co

Laundry Machinery:
Bradford, T., and Co
Summerscales, W., and Sons
Tullis, D. and J., Ld

Lead Machinery:
Wilson, J., and Son

Lifts and Hoists:
Gimson and Co., Ld
Holt and Willetts
Smith and Stevens
Sykes, H., Ld
Waygood, R., and Co., Ld
Youngs

Light:
Wells, A. C., and Co

Lithographers:
Cook and Hammond

Locks:
Kaye, J. and Sons, Ld

Locomotives:
American Locomotive Co
Avonside Engine Co
Bagnall, W. G., Ld
Beyer, Peacock and Co., Ld
Borsig, A.
Burnham, Williams and Co
Davies and Metcalfe, Ld
Hawthorn, Leslie and Co., Ld
Henschel and Sohn
Hudswell, Clarke and Co
Hunslet Engine Co., Ld
Kerr, Stuart and Co., Ld
Locomotive and Machine Co. of Montreal
Lowca Engineering Co., Ld
North British Locomotive Co., Ld
Peckett and Sons
Stephenson, R., and Co., Ld
Vulcan Locomotive Works

Lubricators:
Hulburd Engineering Co
Hunt and Mitton
Trier Bros.
Wakefield, C. C., and Co

Machine Tools *(see* Tools)

Manganese Steel Castings & Forgings
Allen, E., and Co., Ld
Hadfield's Steel Foundry Co

Marine Machinery:
Renfrew Bros. and Co

Mathematical Instruments:
Davis, J., and Son, Ld
Negretti and Zambra
Stanley, W. F. and Co. Ld

Merchant Iron:
Dunkerley, C. C., and Co. Ld
Farnley Iron Co., Ld
Henderson and Glass
Henschel and Sohn
Measures Brothers, Ld
Pearson and Knowles Coal Co

Metal Perforators:
Barns, W., and Sons

Metals:
Bull's Metal & Melloid Co., Ld
Delta Metal Co., Ld
Glacier Anti-Friction Metal Co., Ld
Magnolia Metal Co., Ld
Phosphor Bronze Co., Ld
Tandem Smelting Syndicate,

Meters:
Glenfield and Kennedy, Ld

Mica:
Wiggins, F. and Sons

Mining Machinery:
Davey, Paxman and Co., Ld
Head, Wrightson and Co., Ld
Robey and Co., Ld
Sandycroft Foundry Co., Ld
Walker Brothers, Wigan

Motor Cars:
Carter Steam Wagon Co
Mann's Patent Wagon Co
Naylor and Co., Ld
St Pancras Ironwork Co., Ld
Thornycroft, J. I., & Co., Ld
Yorkshire Steam Wagon Co

Motor Rollers:
Barford and Perkins

Moulding Machines:
Jackman, J. W., and Co
Samuelson and Co., Ld

Oil Cans:
Kaye, J., and Sons, Ld

Oil Engines:
Blackstone and Co., Ld
Britannia Engineering Co., Ld
Campbell Gas Engine Co., Ld
Crossley Brothers, Ld
Dudbridge Ironworks, Ld
Fielding and Platt, Ld
Gardner, L., and Sons
Hardy and Padmore, Ld
Hornsby and Sons, Ld
Mirrlees Watson Co., Ld
Pollock, Whyte and Waddell
Tangyes Limited
Vosper and Co., Ld

Oil Extractors:
Baker's Patent Appliances, Ld
Haigh, W. B., and Co., Ld
Holden and Brooke, Ld

Oil-gas Apparatus:
Mansfield E., and Sons

Oil Launches:
Vosper and Co., Ld

Oilless Bushes and Bearings:
Fleming, Birkby & Goodall, Ld

Oil Mill Machinery:
Rose, Downs & Thompson, Ld

Oils and Lubricants:
Hurst, James, Ld
Price's Patent Candle Co
Stern-Sonneborn Oil Co
Trier Brothers

Packing, Metallic:
Cooper, E., and Co., Ld
Green and Boulding, Ld
Hobdell, Way and Co., Ld
Hudson, J., & Co., Successors
Hulburd Engineering Co
Klinger, R., and Co
Lancaster and Tonge, Ld
Moseley, D., and Sons, Ld
United Asbestos Co., Ld
U.K. Metallic Packing Synd.
U.S. Metallic Packing Co., Ld
Walker, J., and Co

Paints:
Morris and West
Silicate Paint Co

Painting Machines:
Wells, A. C., and Co

Patent Agents:
Alexander, E. P., and Son
Harris and Mills
Jensen and Son
Redfern, G. F., and Co
Roots, J. D., and Co
Vaughan and Son
Watkin, S., Son and Groves

Pattern Makers:
Brown, D., and Sons, Ld

Pattern Wood:
Owen J., and Sons Ld

Pens and Pencils:
Gillott J. and Son

Photo Printing:
Halden, J., and Co

Pig Iron:
Clay Cross Co
Lilleshall Co

Pile Drivers:
Lidgerwood Manuf'g Co
Nasmyth, Wilson and Co., Ld

Piles, Steel and Concrete:
Williams, S., and Sons, Ld

Pipes, Iron & Steel:
Clayton, Son and Co., Ld
Laidlaw, R., and Son
Meehan and Sons
Piggott, T., and Co., Ld
Stewarts and Lloyds, Ld

Pistons:
Lancaster and Tonge, Ld
Lockwood and Carlisle, Ld

Plummer Blocks:
Jardine, J.
Unbreakable Pulley Co., Ld
Wigglesworth, F., and Co. Ld

Pneumatic Tools:
Consolidated Pneumatic Tool Co., Ld
Globe Pneumatic Engineering Co., Ld
Howard Pneumatic Eng'g Co
Industrial Engineering Co
Macdonald, J., and Son, Ld
Pneumatic Engineering Appliances Co
Ross, R. G., and Son

Powder Coal Plant:
Schwartzkopff Firing Synd.

Presses:
Hands, J., and Sons
Rhodes, J., and Sons, Ld
Taylor and Challen, Ld

Printing and Stationery:
Reveirs, Geo.

Pulleys:
Bagshaw, J., and Sons, Ld
Crowther, H., and Sons, Ld
Douglas, Lawson and Co
Garnett, P. and C., Ld
Gimson and Co., Ld
Harpers Limited
Mackies, Ld
Reid, W., and Co
Smith and Grace
Unbreakable Pulley Co., Ld.

Pulverisers and Quartz Mills:
Bradley Pulveriser Co
Schwartzkopff Coal Dust Firing Syndicate

Pumps:
Allen, W. H., Son and Co., Ld
Bailey, W. H., and Co., Ld
Batchelor, R. D.
Brackett, F. W., and Co
Caird and Rayner
Cameron, J., Ld
Carruthers, J. H., and Co
Cochrane, John
Drum Engineering Co
Drysdale, J., and Co
Evans, J., and Sons
Fleming and Ferguson, Ld
Glenfield and Kennedy, Ld
Gwynnes Limited
Hall, J. P., and Sons, Peterboro
Hathorn, Davey and Co., Ld
Hayward-Tyler and Co
Hughes and Lancaster
Marx, J., and Co
Mather and Platt, Ld
Mumford, A. G., Ld
Nasmyth, Wilson and Co., Ld
Owens, S., and Co
Pearn, F., and Co., Ld
Pulsometer Engineering Co., Ld
Reader, E., and Sons, Ld
Richards, R., and Co
Simpson, J., and Co., Ld
Tangyes Limited
Thwaites Brothers, Ld
Warner, R., and Co
Weir, G. and J., Ld
Westinghouse Brake Co., Ld
Wilcox, W. H., and Co., Ld
Wilson, J., and Son
Worthington Pump Co., Ld

Pyrometers:
Crompton and Co., Ld

Railway Plant:
Askham Bros. and Wilson, Ld
Bagnall, W. G., Ld
Baker, J., and Co. (Rotherham)
Birch, J., and Co., Ld
Bolling and Lowe
Continuous Rail Joint Co
Cravens, Limited
Dennis, W. F., and Co
Dick, Kerr and Co., Ld
Findlay, A., and Co
Fowler, J., and Co., Ld
Glasgow Railway Engin'g Co
Green, T., and Sons, Ld
Griffith, W., and Sons
Harrison and Camm, Ld
Hudson R.
Isca Foundry Co
Kerr, Stuart and Co., Ld
Laycock, W. S., Ld
Leeds Forge Co., Ld
Lion Spring Co
Maclellan, P. and W., Ld
McLachlan and Co
Midland Railway Carriage Co
Patent Shaft and Axletree Co
Ransomes and Rapier, Ld
Renshaw, W. R., and Co., Ld
Stableford and Co
Summerson, T., and Sons, Ld
Turner, G. R., Ld
United Electric Car Co., Ld

Rams, Hydraulic:
Blake, J., Ld
Vacher, H. P.

Reducing Valves:
Royles Limited

Refrigerating Machinery:
Farringdon Works and H. Pontifex and Sons Ld
Hall, J. and E., Ld
Haslam Foundry and Engineering Co., Ld
Linde British Refrigeration Co
Pulsometer Engineering Co
Sterne, L., and Co. Ld

Rock Drills:
Daw, A. and E.

Rolls and Rolling Mill Plant
Akrill, C., and Co., Ld
Krupp-Grusonwerk, F.

Roofs *(see* Iron Build'gs)

Rust Preventer:
Elsy Bros. Ld

Sand Mixers:
Hall, J. S., and Co., Ld

Sand Washers:
Krupp Grusonwerk, F.

Saw Mill Machinery *(see* Woodworking Machinery)

Screwing Tackle:
Chatwin, T.
Hulse and Co., Ld
Widdowson, J. H.

Shafting:
Crowther, H., and Sons
Govan Shafting Co
Harpers Limited
Platt, S., Ld

Shearing Machines:
Jones, Geo., Ld
Perry, T., and Son, Ld

Sheet Metal Work:
Donovan and Co., Ld
Standard Engineering Co., Ld

Shunting Levers:
Taylor's Patent Shunting Levers

Soda Water Machinery:
Barnett and Foster

Steam Engines:
Brazil, Holborow and Straker
Brit. Westinghouse Electric Co
Burrell, C., and Sons
Cole, Marchent & Morley, Ld
Dodman, A., Ld
Easton and Bessemer, Ld
Galloways Limited
Hindley, E. S., and Sons
Howden, J., and Co
Lees, T. and R.
Plenty and Son, Ld
Ransomes, Sims and Jefferies
Reader, E., and Sons, Ld
Reavell and Co., Ld
Robey and Co., Ld
Ross and Duncan
Ruston, Proctor and Co., Ld
Samuelson and Co., Ld
Stewart, D., and Co., Ld
Tangyes Limited
Turner, E. R. and F., Ld
Willans and Robinson, Ld
Wilson, A.

Steam Launches:
Cochran and Co., Annan, Ld
Collis, A. B., Ld
Fleming and Ferguson, Ld
Hayes, Ld
Salter Bros.
Simons, W., and Co., Ld
Simpson, Strickland and Co
Yarrow and Co., Ld

Steam Separators:
Haigh, W. B., and Co
Holden and Brooke, Ld
Lancaster and Tonge, Ld

Steam Traps
British Steam Specialities, Ld
Hobdell, Way and Co., Ld
Lancaster and Tonge, Ld
Marsden, John, and Son

Steel:
Allen, Edgar, and Co., Ld
Armstrong, Whitworth & Co
Beardmore, W., and Co
Brown, Bayley's Steel Works,
Brown, J. and Co., Ld
Butterley Co., Ld
Cammell, Laird and Co., Ld
Carbrook Steel Works
Colville, D., and Sons, Ld
Firth, T., and Sons, Ld
Hadfield's Steel Foundry Co
Howell and Co., Ld
Jessop, W., and Sons, Sheffield
Rogerson, J., and Co
Spencer, J., and Sons
Steel Company of Scotland
Stewarts and Lloyds, Ld
Turton, T., and Son
Vickers, Son and Maxim, Ld

Steel Structural Work:
Heenan and Froude, Ld
Main, A. and J., and Co
Meehan and Sons, Ld
Morton, F., and Co., Ld

Stills and Distilling Plant:
Pontifex and Wood

Stokers, Mechanical, &c.:
Bennis, E., and Co., Ld
Haigh, W. B., and Co
Meldrum Bros., Ld
Proctor, Jas.

Stone Breakers:
Baxter, W. H., Ld
Goodwin, Barsby and Co
Marsden, H. R.
Mason Bros.

Suction Gas Plant *(see* Gas Engines)

Sugar Machinery:
Blake, Barclay and Co
Cail Engineering Co
Manlove, Alliott and Co., Ld
Mirrlees Watson Co., Ld
Stewart, D., and Co., Ld

Superheaters:
Central Marine Engine Works
Cruse Superheater Co
Galloways Limited

Tanks:
Ash, J., and Son
Braby, F., and Co., Ld
Clayton, Son and Co., Ld
Davies, T., Ld
Newton, Chambers & Co., Ld

Time Checkers:
Llewellin's Machine Recorders Limited

Tools:
Archdale, J., and Co
Asquith, W., Ld
Atlas Engineering Co
Bateman's Machine Tool Co
Isbergrams Limited
Britannia Engineering Co., Ld
Buck and Hickman, Ld
Buckton, J., and Co., Ld
Burton, Griffiths and Co
Butler, J., and Co
Cameron, J., Ld
Campbells and Hunter
Carron Company
Chambers, Scott and Co
Clifton and Waddell
Cohen, I., and Co

Tools *(continued)*:
Craven Bros., Ld
Crompton and Co., Ld
Daniell, S. A., Ld
Darling and Sellers, Ld
Davis and Primrose
Dean, Smith and Grace, Ld
De Bergue and Co., Ld
Dempster, Moore and Co.
Desp, J., and Co. Ld
Herbert, A., Ld
Hetherington, J., & Sons, Ld
Hill, Isaac and Son
Hulse and Co., Ld
Jones & Lamson Machine Co
Kendall and Gent, Ld
Lang, J., and Sons
Linwood Machine Tool Co., Ld
Loewe, L., and Co., Ld
Melhuish, Rd., Ld
Miley's Machine Tool Co., Ld
Mitchell, D., and Co., Ld
Muir, W., and Co
Noble and Lund, Ld
Parkinson, J., and Son
Pfeil and Co
Pratt, F., and Co., Ld
Redman, C., and Sons
Reinecker, J. E.
Richards, G., and Co., Ld
Ryder, T., and Son
Schuchardt and Schutte
Selig, Sonnenthal, and Co
Shanks, T., and Co
Smith and Coventry, Ld
Smith, G. F., Ld
Smith, Hugh, and Co
Smith, T., & Sons, of Saltley
Stirk, J., and Sons
Tangye Tool and Electric Co
U.S. Metallic Packing Co., L
Ward, H. W., and Co
Ward, T. W., Ld
Webster and Bennett
Wicksteed, C., and Co
Wilkinson, G., and Sons

Traction Engines
Allen, J. G., and Co
Burrell, C., and Sons, Ld
Fowler, J., and Co. (Leeds
Ransomes, Sims and Jefferies

Tube-making Machines:
Fielding and Platt, Ld
Jones, George, Ld

Tube Mills:
Newell, E., and Co., Ld

Tubes:
Aird, Joseph
Birmingham Battery & Metal Co
British Mannesmann Tube Co
Broughton Copper Co., Ld
Galloways Limited
Grice, Grice and Son
Howell and Co., Ld
Lewis, E., and Sons
Piggott, T., and Co., Ld
Russell, James, and Son
Russell, Jno., and Co., L
Stewarts and Lloyds, Ld
Weldless Steel Tube Co., Ld

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Re Brooke, Simpson, and Spiller (Ltd.).—By order of the High Court of Justice. – Freehold Waterside Manufacturing Property at Hackney Wick.—With possession.—Messrs.

Fuller, Horsey, Sons & Cassell will (unless previously disposed of by private treaty) offer for SALE by AUCTION, at the Mart, Tokenhouse-yard, E.C., on WEDNESDAY, July 18th, at One o'clock precisely, the following

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known as the ATLAS ANILINE COLOUR and PRINTING INK WORKS, situate on the Windsor-road, Hackney Wick, N.E., which will be offered first in one lot, and if not thus sold, then in three lots, as under:—

LOT 1.—A FREEHOLD FACTORY, having a frontage to Windsor-road of 138ft., to the Hackney Cut Navigation of 127ft., and a ground area of about 54,000 sq. ft., of which about 30,000 sq. ft. are covered with substantial ground floor brick buildings.

LOT 2.—A FREEHOLD FACTORY, having a road frontage of 125ft., a water frontage of 195ft., and a ground area of about 75,000 sq. ft. The buildings are mostly of brick, of ground floor only, and cover an area of about 39,000 sq. ft.

LOT 3.—A FREEHOLD FACTORY, having a frontage to the road of 137ft., to the Hackney Cut of 250ft., and an area of over 1¼ acres, of which 14,000 sq. ft. are covered with ground-floor brick buildings, including boiler-house, fitted with two Lancashire boilers.

Note.—The purchasers of the freeholds will have the option of taking over the fixed plant and machinery in their respective lots, at a fixed sum to be stated in the particulars, and in the event of their not exercising this option the vendor will remove such machinery before completion.

The works may be viewed by orders to be obtained of the Auctioneers; plans and conditions of sale had of Messrs. Morley, Shirreff and Co., Solicitors, 53, Gresham House, Old Broad-street, E.C.; of Messrs. Michael Abrahams, Sons and Co., Solicitors, 5, Tokenhouse-yard, E.C.; of Messrs. Baillie and Co., Solicitors, 15, George-street, Mansion House, E.C.; of the Liquidator, J. H. Champness, Esq., F.C.A., 103, Cannon-street, E.C.; of the Receiver, H. Wingfield, Esq., F.C.A. (of Messrs. Fairbairn and Wingfield), 64, Cannon-street, E.C.; and of Messrs. FULLER, HORSEY, SONS and CASSELL, 11, Billiter-square, E.C. 2257

Re B. Birnbaum and Son (Ltd).—By order of the Trustees for the Debenture Holders.—Extensive Freehold Manufacturing Properties at Old Ford, with immediate possession.—Messrs.

Fuller, Horsey, Sons & Cassell will (unless previously disposed of) offer for SALE by AUCTION, on the premises, on TUESDAY, July 24th, at Eleven o'clock precisely, the WICK-LANE RUBBER WORKS, Old Ford, E., first in One Lot, and if not thus sold, then in Two Lots, as under, the following

FREEHOLD FACTORIES:

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LOT 2.—The CLOTHING FACTORY on the opposite side of Smeed-road (communicating with the above works by means of two bridges), having an extensive frontage thereto, and also to Dace-road, occupying a ground area of about 15,200 square feet, mostly covered with substantial brick buildings, exceptionally well lighted, containing a floor space of about 23,000ft.

The works may be viewed by orders, to be obtained of the Auctioneers, and particulars, plan, and conditions of sale had of Messrs. Gribble and Co., Solicitors, 38, Bedford-row, W.C.; of R. F. W. Fincham, Esq., C.A., 3, Warwick-court, Holborn, W.C.; and of Messrs. FULLER, HORSEY, SONS and CASSELL, 11, Billiter-square, E.C. 2258

Re B. Birnbaum and Son, Ltd.—By order of the Trustees for the Debenture Holders.—To India-rubber Manufacturers, Waterproofers, Waterproof Canvas and Clothing Manufacturers, Engineers, and others.—Messrs.

Fuller, Horsey, Sons & Cassell are instructed to SELL by AUCTION, in lots, on the premises, Dace-road and Smeed-road, Wick-lane, Old Ford, E. (lately in the occupation of Messrs. B. Birnbaum and Son, Ltd.), on TUESDAY, July 24th, at Eleven o'clock precisely, INDIARUBBER PLANT AND MACHINERY, including two masticators, three dough mixers, two dough presses, 16 pairs washing, grinding, mixing, and solution rolls, two sets calender rolls, sifting and dressing machines, measuring and doubling machines, 15 spreading machines, 7 6in. printing machine, with pair diagonal engines, three farina machines, sulphuring machine, four vulcanising cylinders, drying machines and drying cylinders, six screw presses, 12 eyeletting and cutting machines, 90 sewing machines, 10 jacket pans, hot plates, &c., drying rooms and fittings, zinc-covered measuring and desk-cutting benches, iron and wood dough boxes, &c., five lathes, planing, shaping, screwing machines, engineers' and smiths' tools, saw bench, mortising machine, two compound Lancashire and multitubular boilers, Tangye's "special" steam pump, 10 tanks and cisterns, five horizontal and vertical steam engines, four electric motors, well and other pumps, six hoists, lifts and cranes, shafting, pulleys, leather and other driving bands, weighing machines, vices, benches and fittings, steam and water piping, coils, and fittings, two safes, office furniture, and other effects.

May be viewed, and catalogues had, as in preceding advertisement. 2259

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